

CALIFORNIA PATH 1996 ANNUAL REPORT



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Overview of California PATH

The California Partners for Advanced Transit and Highways Program (PATH) has been leading the way in ITS (Intelligent Transportation Systems) research since PATH's founding in 1986, before the term ITS or its predecessor IVHS (Intelligent Vehicle Highway Systems) had even been coined.

PATH's purpose is to develop the foundations for the widespread adoption of advanced technologies that will help improve the operation of California's surface transportation systems. In order to develop these foundations, PATH needs to identify impediments to progress, both technical and institutional, and develop strategies for overcoming those impediments. The PATH charter includes conducting leading-edge research, evaluating operational tests, developing public/private/academic partnerships, and educating both students and practitioners about ITS. However, it does not extend as far as deployment or operation of systems, which remain the responsibilities of the Caltrans district office operations and the relevant local agencies.

A key element of the PATH Program philosophy is the significant emphasis on areas that offer potentially dramatic improvements in the operations of the transportation system, relative to those that can make only incremental improvements. The growth of population and travel demand is so rapid in California that the effects of the incremental solutions are likely to be absorbed in this growth by the time they are implemented. At the same time that PATH addresses the relatively long-term, high-impact solutions, it also addresses the progressive steps that will be necessary to get to the long-term solutions.

The types of ITS research and development activities that occur under PATH auspices include:

- identification of problems and needs
- basic technological research on enabling technologies
- applied technology research and development
- system-level design and evaluation
- experimental verification of design predictions
- evaluations of existing technologies or equipment
- evaluations of costs and benefits
- technology assessments
- human interface evaluations
- predictions of behavioral responses of users
- predictions of impacts of use of technologies
- evaluations of legal and institutional issues.



Caltrans has provided the majority of the funding for the PATH Program, based on the desire to promote the development of new technology and knowledge that can be used to improve the productivity, safety and environmental impacts of the operations of California's surface transportation systems.

The program is managed by the Institute of Transportation Studies of the University of California at Berkeley, which has established the PATH Program headquarters at

the University's Richmond Field Station. Policy issues are addressed by the PATH Executive Committee in the University and the Caltrans-PATH Joint Management Team, which is comprised of program managers from both Caltrans and the University. The day-to-day operations of the program are managed by the PATH Program Office staff.

PATH has about 50 full-time staff members, including program management and administration as well as a core group of research staff members. The majority of the PATH research is conducted on the campuses of the university partners, employing graduate students supervised by faculty members. A substantial body of research is also conducted by the full-time research staff at the PATH Program office. These are supplemented by subcontracts to private companies as needed and by cooperative research agreements with a variety of organizations, including private companies as well as public institutions, both domestic and overseas. The more product-development oriented work of the private companies can serve to complement the more basic work of the academic researchers, so that each can concentrate on that to which it is best suited.



PATH Activities in National ITS Program

Although about 80% of PATH's funding has been provided by Caltrans, the program has also had substantial funding from the Federal Department of Transportation (DOT). This has included support from the Federal Highway Administration (FHWA), Federal Transit Administration (FTA), and National Highway Traffic Safety Administration (NHTSA) on a variety of projects that predated the current DOT programs in ITS. The current PATH participation in DOT ITS programs includes:

- FHWA-Caltrans cooperative agreement for research on vehicle-follower longitudinal control;
- ITS System Architecture Program, subcontractor to the Rockwell team in phases 1 and 2, focusing on evaluation of transportation impacts of the ITS architecture;
- Human Factors Design of Automated Highway Systems (AHS), subcontractor to Honeywell focusing on definition of AHS operational scenarios and functions to provide the bases for developing the human factors experiments;
- PATH is one of the ten core participants in the National Automated Highway System Consortium (NAHSC), which began a seven-year effort to conduct the System Definition Phase of the AHS program in October 1994. PATH researchers will be active in most of the tasks of the NAHSC work plan, and have the lead responsibility for developing AHS modeling and analysis tools. They will also be working heavily on: 1) evaluation and development of enabling technologies for AHS, 2) development of an AHS demonstration (scheduled for 1997), 3) evaluation and selection of AHS operating concepts, and 4) design and development of a prototype AHS.

- Evaluation of California ITS Operational Tests:

- TravInfo (Bay Area)
- Smart Call Box (San Diego)
- Adaptive Traffic Control (Anaheim)
- Integrated Ramp/Signal Control (Irvine)
- Mobile Surveillance (Orange County)
- Wireless Spread Spectrum Communication (Los Angeles)

State-Funded Core Program of ITS Research

The core of the PATH program is its collection of research projects funded by the Caltrans New Technology Program. Currently, there are about 65 such projects, which are selected on the basis of an annual Request for Proposal (RFP) and proposals submitted from throughout California. These involve the work of about 60 professors, representing 26 academic departments on ten different university campuses, supervising the research of over a hundred graduate students and post-doctoral researchers. When this effort is combined with that of the PATH Program Office staff, it represents a total annual investment of about \$6 million of state funding. The current projects are being conducted at: University of California at Berkeley, University of California at Davis, University of California at Irvine, University of California at Los Angeles, University of California at Riverside, University of Southern California, California Polytechnic State University at San Luis Obispo, San Diego State University, The Claremont Graduate School, and University of Washington.

PATH activities are subdivided into three broad categories:

- ATMIS - Advanced Transportation Management Information Systems (which includes the more traditional categories of ATMS, ATIS and APTS);
- AVCS - Advanced Vehicle Control Systems (which includes Automated Highway Systems - AHS);
- Systems - the cross-cutting and institutional issues that apply to both ATMIS and AVCS, as well as communications and system architecture.

The project descriptions that follow are organized in these three groupings.



Current PATH Research Projects

PATH Research

ATMIS—Advanced Transportation Management Information Systems

APTS—Advanced Public Transportation Systems

ATIS Field Operational Test Evaluation Studies: Real-Time Rideshare Match/Pre-trip Planning

Paul Jovanis, Civil Engineering, University of California, Davis; Ryuichi Kitamura, Transportation Engineering, Kyoto University

A study of the effectiveness of advanced traveler information and planning systems. The areas selected for evaluation are real-time rideshare matching systems and pre-trip planning systems.

Functional and Interface Requirements for APTS

Mark Hickman, PATH Headquarters

This project will analyze the need for interface standards among information systems and APTS technologies at public transit agencies. This requires a detailed review of data, functional and interface requirements within a transit agency. Supplementing this review are case studies at several agencies to examine related technical and management issues.

ITS Applications to Timed Transfer

Randolph Hall, Industrial and Systems Engineering, University of Southern California

A “timed transfer” exists when multiple bus routes are scheduled to arrive on or about the same time at a transit terminal, with the goal of enabling short waiting times. This project investigates the application of ITS technologies to improve timed transfers, and to evaluate the technologies with simulations.

Transit Information Systems Inventory

Mark Hickman, PATH Headquarters

This research examines the current state of information systems at transit agencies throughout California. To this end, the project identifies the current and short-term future data and information requirements, and also examines the organizational and institutional framework that may enhance the use of these information systems.

Using Advanced Technologies to Increase Mobility and Accessibility of Travelers with Special Needs

Paul Jovanis, Civil Engineering, University of California Davis

The objectives of this study are: 1) to define the characteristics, current travel behavior, and needs of travelers with special needs, in particular the elderly, and 2) to propose technological alternatives to increase their safety and mobility.

ATIS - Advanced Traveler Information Systems

• General

Economics of Traffic Information: Production, Dissemination and Use

Adib Kanafani, Institute of Transportation Studies, Pravin Varaiya, Electrical Engineering and Computer Science; University of California, Berkeley

Examines the spatial relationship between demand and supply of traffic information and explores how different suppliers of traffic information distribute themselves spatially along a transportation system. The initial assumption that demand for information is uniform among travelers will be relaxed to explore the effect of differentiated demands depending on location, trip length, traffic intensity, or other factors. Ultimately the researchers hope to develop a model of the economic value of information derived from an understanding of its market structure.



Finding Tractable Ways to Alleviate System-Made Congestion in Large-Scale Networks

Raja Sengupta, PATH Headquarters

It is suspected that the introduction of ATIS services may actually worsen congestion in some traffic conditions: this is "system-made congestion." Our aim is to characterize some of these conditions and investigate ways in which ATIS services may be modified to avoid these counterproductive effects.

Multimode Travel Itinerary Planner

Ryuichi Kitamura, Transportation Engineering, Kyoto University

A Travel Itinerary Planner will generate a day's itinerary based on input such as desired destinations and arrival times. Heuristic algorithms will be developed and existing databases effectively used to produce Planner prototypes. The Planner will aid in promoting public transit and ridesharing for non-commute trips.

TRAVINFO Evaluation

Youngbin Yim, Mark Miller, Stein Weissenberger, PATH Headquarters

This research evaluates the TravInfo Field Operational Test in the San Francisco Bay Area. TravInfo is a public/private partnership formed to provide widespread dissemination of real-time information on transportation conditions and travel options. The evaluation covers many dimensions: traveler response, institutional issues, technology assessment, and network performance.

• Human Factors

Alternative Traffic Signal Illumination: A Human Factors Study

Theodore E. Cohn, Optometry, University of California, Berkeley

Examines the visual effects of a range of possible energy and maintenance cost saving alternatives to standard incandescent traffic signal lamps in order to see whether the new alternative lamps convey the same safety information as their expensive predecessors.

California Advanced Driver Information System II

Paul Jovanis, Civil Engineering, University of California, Davis

This study identifies and evaluates the human-factors design considerations for maximizing the effectiveness of CADIS in-vehicle systems, eliminating or significantly reducing unsafe operations, and optimizing the driver-vehicle interface.



ATMS - Advanced Transportation Management Systems

• Incident Management

Development, Testing and Evaluation of Advanced Techniques for Freeway Incident Detection

Stephen Ritchie, Institute of Transportation Studies, University of California, Irvine

The techniques examined are based on a common database containing actual incident data. Approaches include neural networks from the field of artificial intelligence, filtering methods for preprocessing traffic data to reduce the likelihood of false incident decisions from unexpected, short-duration traffic disturbances, and algorithms derived from consideration of catastrophe theory concepts applied to freeway traffic flows.

Evaluation of Freeway Service Patrol at a Los Angeles Freeway Site

Alex Skabardonis, Institute of Transportation Studies, University of California, Berkeley

Evaluates the costs/benefits of the Freeway Service Patrol on a specific beat in the Los Angeles Freeway system. Also develops a comprehensive database on freeway operating conditions similar to the one developed for the I-880 test site.

• Pricing

Congestion Pricing on Trucking Operations

Hong K. Lo, Mark Hickman, PATH Headquarters

Will conducts a detailed literature review of trucking operations, with the goal of examining how congestion pricing may fit into operation decisions. The study will then focus on developing a framework for assessing congestion pricing impact on trucks. The framework identifies modeling tools and data requirements for analyzing this impact.

Road Pricing and IVHS

Hong Lo, PATH Headquarters

A survey of topics important for the investigation of pricing schemes within an ITS context, through literature review and interviews with experts. Topics covered include: pricing interaction with other traffic demand management tools, pricing and inter-modal coordination, dynamic pricing schemes, emissions pricing and combined emission/congestion pricing, system performance effects, traveler behavior effects, and tolls for highway cost recovery.

• Signal Control

Control Strategies for Transit Priority Alex Skabardonis

Institute of Transportation Studies, University of California, Berkeley

The objective of this research is to develop, design and test traffic control measures in urban networks to provide priority to transit and other high occupancy vehicles (HOVs), as well as to evaluate their impacts on both priority and non-priority vehicles.

Design of a Machine-Vision Based, Vehicle-Actuated Signal Controller

Mike Cassidy, Civil Engineering, University of California, Berkeley

We are assessing the impacts of applying machine-vision detection systems to control signalized intersections. Unlike existing control systems, which often rely on “point” detectors to infer queuing conditions, a machine-vision system will utilize information about conditions at all points on the intersection approaches. We anticipate reductions in motorist delays and improved safety.

Evaluation of the City of Anaheim Advanced Traffic Control System Field Operational Test

Art MacCarley, Electronic/Electrical Engineering, California Polytechnic State University, San Luis Obispo

A systematic evaluation of the performance and effectiveness of this FOT. The test has two key technical features: arterial traffic control supervised by the SCOOT (Split Cycle and Offset Optimization Technique) algorithm, and a VTDS (Video Traffic Detection System) developed by Odetics Corporation.

Evaluation of the City of Irvine Integrated Freeway Ramp Meter/Arterial Adaptive Signal Control Field Operational Test

Art MacCarley, Electronic/Electrical Engineering, California Polytechnic State University, San Luis Obispo

A systematic evaluation of the performance and effectiveness of this FOT. The Irvine FOT involves an integrated and jointly managed Advanced Transportation Management System(ATMS) that extends the capabilities of the existing freeway and arterial traffic management systems in the Irvine area of Orange County. The primary objective is to integrate and coordinate a centrally controlled freeway Ramp Meter System (RMS) with an arterial traffic management system.

Impacts of Signal Coordination Approaches

Hong K. Lo, Wei-Hua Lin, PATH Headquarters; Alex Skabardonis, Institute of Transportation Studies, University of California, Berkeley

Signal coordination is often considered as an essential tool for traffic congestion mitigation. Since it often requires more detectors and equipment, it is important to determine its cost-

PATH Research



effectiveness. This study seeks to examine the impacts of various signal coordination approaches. It highlights the various assumptions adopted in the different approaches, and uses a simulation platform to validate the assumptions and evaluate their associated impacts.

• Surveillance

Estimation of Travel Time Distribution and Detection Incidents Based on Automatic Vehicle Classification

Venkat Anantharam, Electrical Engineering and Computer Science, University of California, Berkeley

Automatic vehicle classification is feasible with current vehicle detector technology. The goal of the research is to develop pattern-matching algorithms that use data from several detectors deployed along a freeway section to yield estimates of the travel time distribution of vehicles and indicators of congestion and of incidents.



Evaluation of Mobile Surveillance Field Operational Test

Stephen Hockaday, Civil & Environmental Engineering, California Polytechnic State University, San Luis Obispo

This FOT in Orange County assesses the increased effectiveness of an integrated mobile system that provides video image processing, transportable ramp metering, and direct vehicle-roadside communications. The mobile system is compared to traditional traffic-detection methods.



Machine-Vision Based Surveillance System for California Roads

Jitendra Malik, Stuart Russell, Electrical Engineering and Computer Sciences, University of California, Berkeley

This system uses state-of-the-art image processing and tracking algorithms in an attempt to attain higher levels of accuracy and reliability than have yet been achieved in ATMIS surveillance in real-time. It detects vehicles on the road, tracks their progress through the camera's field of view, identifies each vehicle by generic type (car, van, truck, etc.), and returns coarse information such as traffic speed and flow.



Section-Related Measures of Traffic System Performance

Stephen G. Ritchie, Civil and Environmental Engineering, University of California, Irvine

Demonstrates and evaluates new methods for obtaining true "section-related" performance measures, initially for freeways, based on pattern recognition technology and use of either existing loop detectors or overhead mounted infrared sensors. Results will help determine potential benefits of applying these techniques to congestion monitoring, incident detection, traveler information, and system performance measures.



Study of Advanced Image Sensing Methods for Traffic Surveillance and Hazard Detection

Art MacCarley, Electronic/Electrical Engineering, California Polytechnic State University, San Luis Obispo

A study of alternative imaging technologies for traffic surveillance and detection that have superior ability to "see" through fog and particles, or that do not depend on natural visible-spectrum illumination.



• Traffic Modeling

ATMIS Transportation Modeling Environment

Alex Skabardonis, Institute of Transportation Studies, University of California, Berkeley; Ed Lieberman, KLD Associates; Paul Menaker, KORVE Engineering

This project expands research on the TRAF-NETSIM model to enable it to simulate both the performance of traffic responding to real-time control systems and the actual real-time control environment. Real-time control software interfaces with the microscopic traffic simulation modeling incorporated within TRAF-NETSIM so that the entire control/operations environment can be simulated in microscopic detail.

Dynamic Traffic Models and Input Sensitivity

Jacob Tsao, PATH Headquarters

This research compares the results of a simulation-based and an analytical-based traffic model. An assessment is also made of the precision requirements of time-dependent origin/destination flow data for these models.

Simulation Models of Driver-Vehicle Interactions

Alexander Skabardonis, Institute of Transportation Studies, University of California, Berkeley

The study will develop improved car-following and lane changing models for highway traffic. The models' formulation will consider interactions between car-following and lane changing, driver behavior under different operating conditions, and variability in driver-vehicle characteristics. The improved models will be incorporated into an operational simulation model and will be calibrated and validated with field data.

PATH Research

AVCS - Advanced Vehicle Control Systems

Enabling Technologies

Field Test of Vehicle-Mounted, Forward-Looking, Range and Relative Velocity Sensor in Closed-Loop AVCS

Lon Bell, Amerigon, Inc.

The purpose of this research project is to demonstrate a novel ultra-wideband radar sensor technology recently developed at the Lawrence Livermore National Laboratory. Microwave semiconductors are now mass-produced for the commercial communications market, making them inexpensive and available off the shelf. Amerigon has designed Integrated Domain Radar (IDR), taking advantage of these advanced components to create low-cost devices. USC will evaluate IDR's potential as a primary longitudinal sensor for AVCS applications.



Integrated Microsensors for Vehicle Control

Bernhard Boser, Roger Howe, Richard Muller, Richard White, Electrical Engineering and Computer Sciences; Albert Pisano, Mechanical Engineering, University of California, Berkeley

The project involves the fabrication and demonstration of three stand-alone microsensors: a Force-Balance Microaccelerometer, a Vibrating Rate Gyroscope, and an Ultrasonic Microphone and Transducer. Together these developments are leading to the rugged, low-cost sensors essential to the successful implementation of an automated highway system. This major effort to create high-performance, low-cost microfabricated sensors with integrated electronics is underway at the Berkeley Sensor & Actuator Center (BSAC).



Machine-Vision Based System for Guiding Lane Following and Lane-Change Maneuvers

Jitendra Malik, Electrical Engineering and Computer Sciences, University of California, Berkeley

An intelligent vehicle needs a dynamically updated world model of the vehicles in the neighboring lane - their positions and velocities as well as the position and velocity of self relative to the lane markings. This project investigates the combined use of binocular stereopsis and optical flow information for initiating and updating such a world model. The key steps are segmenting the image into individual vehicles, identifying the lane markers, and then tracking these to maintain a dynamically updated model.

PATH Laboratory

Bret Foreman, PATH

This research work provides support to enabling technology development efforts in three major categories: wireless communications, inertial navigation, and real-time software.

Evaluation

Aerodynamic Studies of Short-Headway Platoons

Frederick Browand, Michael Zabat, Aerospace Engineering, University of Southern California

These studies determine the drag, side force, and yawing moment that acts on various vehicles, based on wind-tunnel testing of 1/8 scale GM APV vans in platoons of two, three, and four vehicles in the Dryden Wind Tunnel at USC. Vehicle drag is shown to depend strongly upon inter-vehicle spacing, implying that fuel economy can be improved by appropriate separation distances. Coast-down testing of full-scale vehicles to validate tunnel measurements is in preparation.

Transient Aerodynamic Vehicle Interaction

Omer Savas, Mechanical Engineering, University of California, Berkeley

When a vehicle joins or leaves a platoon, aerodynamic forces on it and the other platoon members change: these effects are especially important when headways are much shorter than vehicle size. Wind tunnel tests of these transient forces are planned using 1/18 scale models. This research will provide unsteady forcing functions for control algorithms developed in the Mechanical Engineering Department at UCB for PATH.

Safety

Fault Detection and Identification with Application to Advanced Vehicle Control Systems

Jason Speyer, Mechanical, Aerospace, and Nuclear Engineering, University of California, Los Angeles

The purpose of the research is to improve the fault-tolerance of advanced vehicle control systems by developing and applying fault detection and identification technology, using an analytic redundancy scheme known as a detection filter. Main objectives are to: 1) improve the robustness of the detection filter by better accounting for disturbances, sensor noise, and modeling errors; 2) describe the statistical properties of the detection filter output for a meaningful assessment of false alarm and miss alarm rates; 3) develop a fault identification system where several detection filters operate in parallel.

Intelligent Diagnosis Based on Validated Fused Sensor Data for Reliability and Safety Enhancement of Automated Vehicles in an IVHS

Alice M. Agogino, Kai Goebel, Mechanical Engineering, University of California, Berkeley

An intelligent decision adviser is proposed that forecasts potential hazards and provides recommendations on potential maneuvers and actions to the coordination level controller in an optimal manner. This supervisory controller, using validated fused data, serves as a link between the vehicle sensors and the coordination layer and ensures the proper operation of the system in diverse and adverse operating conditions.

Models of Vehicular Collision: Development and Simulation Emphasis on Safety

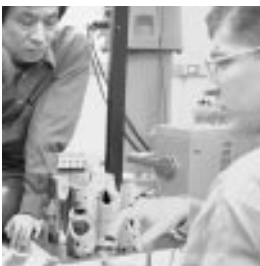
Oliver O'Reilly, Panos Papadopoulos, Department of Mechanical Engineering, University of California, Berkeley

The objective of this project is the development of simple predictive models for vehicular impacts and collisions. The models will be capable of capturing in an averaged sense the basic response characteristics of the vehicular motion. These models will serve as a testing ground for the computational simulations and safety analysis of platoon dynamics.

Safety Considerations of Advanced Technology

J. Bret Michael, PATH Headquarters

To be acceptable, AVCS technology must offer significant improvements in the casualty rate without compromising the achievement of congestion-related and environmental goals. This can only be achieved if safety is considered in the research, development, design, construction, and operational phases of the project on a systematic basis as part of the whole. The purpose of this work is to develop principles and methods by which safety considerations can be so integrated and to demonstrate them by example.



Safety Design Verification and Validation for Computerized Process Control Systems

Nancy Leveson, Computer Science and Engineering, University of Washington

The objective of this research is to develop an integrated set of safety analysis procedures to validate system safety in systems where computers provide control. The introduction of computer control into electromechanical systems has created new and unsolved problems for both system and software engineers. Our research involves taking system safety approaches that have been developed and proven successful in the defense and aerospace arenas and adapting them to automated highway problems.

Safety Evaluation of Vehicle Following Operations by Fault Tree and Sensitivity Analysis

Ching-Yao Chan, J. Bret Michael, Andrew Segal, PATH

Uses fault tree and other safety tools to evaluate safety issues in vehicle following operations. This project focuses on causes of potential failures and vehicle behaviors under abnormal conditions. The factors to be addressed include platoon dynamics, vehicle engine dynamics, sensors and actuators, communication systems, and control algorithms.

Studies of Collisions in Vehicle Following Operations by Two-Dimensional Impact Simulation

Ching-Yao Chan, PATH Headquarters

Uses two-dimensional simulation models to investigate collisions in vehicle following operations. Through computer simulations, this study analyzes the effects of operating conditions on the vehicle damage and post-impact vehicle motions. The operational parameters considered in the study include vehicle steering and braking, vehicle spacing and speeds, impact orientation and offset, and vehicle classes.

Testing, Verifying, and Validating Critical Real-Time Vehicle Control Software

Andrew Segal, PATH

An extension of previous work. The project focuses on the software embedded in PATH's experimental system for lateral and longitudinal control of a vehicle. Scope includes analysis of the existing software, testing of the software to determine failure modes, and vehicle testing to validate the conclusions drawn from analysis and testing.

PATH Research

System Design

AHS Network Layer for SmartPath

Pravin Varaiya, Electrical Engineering and Computer Science, University of California, Berkeley

This project concerns the development of the network layer, the highest layer of a four layer hierarchical control architecture for an AHS. This project will develop a network layer model, the interface between the network and link layer, and a computer model of the network layer in SmartPath.

Analysis of AHS Architectures and Design of Safe Switched and Feedback Based Maneuvers

R. Horowitz, Mechanical Engineering, S. Sastry, Electrical Engineering and Computer Sciences, University of California, Berkeley

Consistent models of increased abstraction and stabilizing control laws are being formulated for the link and network layers of the PATH AHS architecture. New tools are being developed for analyzing the dynamic and feedback interaction between these layers and the coordination and regulation layers. Feedback based control laws for platoon leaders, and the switching between them, will be designed to guarantee safety under normal or degraded modes of operation.



Evaluation and Analysis of Automated Highway System Concepts and Architectures

Petros Ioannou, Center for Advanced Transportation Technologies, University of Southern California

Goals are: a) To investigate the intervehicle spacing requirements for several AHS concepts and use them to obtain capacity estimates. b) To investigate the spacing and synchronization of vehicle speed and acceleration/deceleration requirements for automatic lane changing for several AHS concepts (these requirements will be used to evaluate the effect of lane changing on capacity). c) To use the results on spacing and lane changing to modify existing traffic flow models for several AHS concepts and use them to examine stability of flows and design link layer controllers that will improve stability and performance.

Performance of Hybrid (Automated/Nonautomated) Freeways

Carlos Daganzo, Civil Engineering, Michael Cassidy, Institute of Transportation Studies, University of California, Berkeley

Automated vehicles can travel on all lanes, but non-automated vehicles cannot. This project develops a macroscopic theory and associated computer software to predict the effect transient phenomena such as disruptions to flow in automated and non-automated lanes may have on ITS system performance. Success in this endeavor will assist in the design of the interface of an AHS with the conventional highway network, and in the development of effective measures to handle disruptions to flow.



Verification of AHS Vehicle Maneuver Design

Pravin Varaiya, Electrical Engineering and Computer Science, University of California, Berkeley

PATH researchers have proposed a five-layer hierarchical control architecture for an Automated Highway System. The coordination layer plans and coordinates the maneuvers of a group of neighboring vehicles. This work develops hybrid systems models, well suited for computational treatment, to provide a computational framework in which the coordination and regulation layers can be formulated together and verification of maneuver designs can be facilitated as well.

Vehicle Control

Analysis, Design and Evaluation of AVCS for Heavy-Duty Vehicles

Ioannis Kanellakopoulos, Electrical Engineering, University of California, Los Angeles

This project focuses on designing nonlinear control schemes that explicitly recognize the performance differences between light-duty and heavy-duty vehicles, and that also provide improved fuel efficiency, enhanced highway safety, and increased traffic flow. Proposed multi-stage nonlinear controllers deliver significantly greater safety margins than conventional control schemes. The schemes are evaluated both through numerical and visual simulations, and experimentally on full-scale vehicles.

Brake System Modeling Control and Integrated Brake/Throttle Switching

Karl Hedrick, Mechanical Engineering, University of California, Berkeley

Extends current work in brake modeling and control and integrates it with other vehicle systems, e.g. engine and chassis subsystems. A fluidic model of the master cylinder and brake hydraulics has been developed, and this model has opened an avenue for developing a better brake controller. Switched control has been achieved using Filippov's theory on differential inclusions.

Development and Experimental Evaluation of Autonomous Vehicles for Roadway/Vehicle Cooperative Driving

Petros Ioannou, Center for Advanced Transportation Technologies, University of Southern California

A study of Autonomous Intelligent Cruise Control (AICC) systems as part of an intelligent roadway/vehicle system in which the AICC controls vehicle longitudinal following while the roadway commands vehicle speeds and intervehicle spacings. Research concentrates on developing and selecting control algorithms for the vehicle and roadway, then analyzing them for robustness using computer simulations and full-scale PATH test vehicles.



Effect of Vehicle Incompatibilities within a Platoon

Benson Tongue, Andrew Packard, Mechanical Engineering, University of California, Berkeley

Examines how platoon operating parameters can be adjusted to account for non-uniform vehicles within the platoon. The main approaches are the use of vehicle specific intraplatoon spacings and the implementation of explicit variations of the individual vehicle's control parameters.

Experimental Studies on Vehicle Lateral Control Systems

Han-Shue Tan, PATH Headquarters

These studies continue PATH efforts to experimentally investigating sensing and control techniques for the vehicle lateral control as a part of an integrated vehicle control system. It is aimed to advance the current level of technology with the emphasis on improving safety and robustness at highway speed. The work includes the development of the following algorithms: robust lateral control, tire burst control, lane-change control and vision based lateral control.

FHWA/Caltrans Cooperative Agreement for Longitudinal Control Research

Steven E. Shladover, PATH Headquarters; J. Karl Hedrick, Mechanical Engineering, University of California, Berkeley

This two-year project provides experimental and enabling technology support to several of the more analytically oriented research projects on longitudinal control and to the National AHS Consortium's development activities. It includes development of performance and testing specifications for ranging sensors, vehicle-to-vehicle communication, and braking actuation systems, followed by testing and evaluation of candidate hardware. This project also supports the development and maintenance of a common in-vehicle real-time control computer hardware and software environment for all PATH AVCS test vehicles, as well as the full-scale testing of longitudinal control hardware and software on a platoon of up to four vehicles.

Integrated Maneuvering Control Design and Experiments

Karl Hedrick, Mechanical Engineering, University of California, Berkeley; Pravin Varaiya, Electrical Engineering and Computer Science, University of California, Berkeley

Integrated maneuvering control of a vehicle consists of regulation control (maintaining desired spacing between two adjacent vehicles in a platoon), and transition control (controlling a vehicle joining or leaving a platoon. This project's goal is to design a controller to follow a joining trajectory. The emphasis is on the switch between regulation control and transition control to ensure a smooth ride. The scope of the project includes developing and testing fully integrated control of complex vehicle maneuvers such as joins, splits, and lane changes.

Integrated Maneuvering Control for Automated Highway Systems Based on a Magnetic Reference/Sensing System

Karl Hedrick, Masayoshi Tomizuka, Mechanical Engineering, University of California, Berkeley

This project develops an integrated longitudinal/lateral control system, based on previous work on separate longitudinal and lateral control systems, and using magnetic markers for additional longitudinal information. The project includes both analytical and experimental work. The research considers the effect of the dynamic coupling of the lateral and longitudinal controllers due to the dependence of the lateral and longitudinal tire forces on the combined lateral and longitudinal slip velocities.

Lane Following and Lane Change Control Algorithms for Vehicle Lateral Control

Masayoshi Tomizuka, Mechanical Engineering, University of California, Berkeley

Investigates lane change maneuvers and continues investigating a fuzzy rule-based controller for lane following for lateral guidance in highway automation. The purpose of the research in lane change maneuvers is to develop a method of bringing a single vehicle from a closed loop lateral control state on one lane to a closed loop state on an adjacent lane in an optimal manner. Simulations include closed loop lateral control on one lane, the lane change maneuver, and closed loop lateral control on the adjacent lane.



Longitudinal Control Development for IVHS

Karl Hedrick, Mechanical Engineering, University of California, Berkeley

This project is directed toward advancing the state of the art in automated vehicle controls for both platoons and adaptive cruise control systems, and toward developing fault-tolerant control methods for highly nonlinear systems. Objectives include adaptive, fault-tolerant, and combined throttle/brake control algorithm development, vehicle platoon simulation, and vehicle experimental validation.

Steering and Braking Control of Heavy-Duty Vehicles

Masayoshi Tomizuka, Mechanical Engineering, University of California, Berkeley

This project characterizes the dynamic response of trucks and buses, identifies key system parameters, and develops control algorithms to achieve automatic guidance. The characteristics of articulated vehicles are thoroughly studied, especially the roll and yaw (fishtail, trailer swing, and jackknife) instability modes. Control algorithms to coordinate steering and braking commands and achieve accurate lane following and platoon spacing are developed, and an experimental study is performed to validate the simulation models and control implementation.

SYSTEMS

Architecture

California Systems Architecture Study

Tom Horan, Claremont Graduate School

Examines the implications of the National ITS Systems Architecture on California ITS deployments. The study will review existing and emerging regional ITS architectures and conduct interviews and focus groups to ascertain key areas of impact and uncertainty. Findings should assist in devising an ITS architecture implementation plan for the state of California.

Los Angeles Field Operational Test - Radio Frequency Networking for Advanced Traffic Control Systems

Victor Li, Electrical Engineering/Systems, University of Southern California

The purpose of this project is to: 1) evaluate the RF Network communications for use in traffic control; 2) evaluate the transfer of test experience for the development and deployment of ITS elsewhere in the country; and 3) compare cost and performance with conventional interconnection technologies.

San Diego Smart Call Box Evaluation

James Banks, Civil Engineering, California State University, San Diego

This field operational test evaluates the feasibility of using field units consisting of microprocessors, solar sources, and cellular phone communications systems to provide communications and data processing capability at remote freeway sites in the San Diego area. The test will include 1) transmission of traffic census data, 2) incident detection, 3) hazardous weather detection, 4) control of Changeable Message Signs (CMS), and 5) control of closed-circuit video cameras.

Systems Architecture with Rockwell

Hong Lo, Mark Hickman, Stein Weissenberger, PATH Headquarters

The goal of this research is to evaluate an ITS architecture as part of the National ITS Systems Architecture Program led by Rockwell International. The PATH team is responsible for developing the overall evaluation methodology, performing an analysis of traffic impacts, and identifying the benefits of the architecture.



General

Database Environment for Fast Real-Time Simulation of Urban Traffic Networks with ATMIS

R. Jayakrishnan, Philip Sheu, Electrical & Computer Engineering, University of California, Irvine

Will develop the environment for using the ATMIS simulation software developed under previous PATH projects for real-time traffic simulation and scenario analysis with feedback from the real urban network. The environment will utilize object-oriented databases.

Identification and Prioritization of Environmentally Beneficial Intelligent Transportation Technologies

Daniel Sperling, Institute of Transportation Studies, University of California, Davis

Identifies a range of ITS technologies and systems that have positive environmental effects (so that they can be environmentally fast-tracked). Results will be used to formulate strategies and designs for enhancing the environmental attractiveness of ITS technologies, including those that yield little or no environmental benefits. The research approach involves policy and regulatory analysis, market research, and emissions and demand modeling.

Object-Oriented Database for IVHS

Pravin Varaiya, Electrical Engineering and Computer Science, University of California, Berkeley

Develops an object-oriented database general enough to integrate traffic simulation packages, data sets, and computational tools. The purpose is to design, build and test a software environment with an open architecture that will greatly facilitate the use of these software elements. The object-oriented database will be implemented in the commercial database system Versant.

Parallel Processing for Fast Traffic Flow Simulation in Real-Time Applications

R. Jayakrishnan, Institute of Transportation Studies, University of California, Irvine

Develops techniques for fast simulation of traffic flow in urban networks using parallel processing. Focuses on the nature of traffic flow and its inherent ability to be parallelized. (Such speed-up is necessary for real-time simulations.) Explores alternative computational platforms for parallel processing and develops guidelines for considering the tradeoffs involved in terms of processing speed, ease of implementation, and to some extent the practical costs involved.

Planning

Decision Support Systems for Managing and Applying ITS Research

Joy Dahlgren, Mark Hickman, PATH Headquarters; Asad Khattak, City and Regional Planning, University of North Carolina; Mohammed Al-Kadri, Caltrans

Potential ITS implementors need information on the performance of ITS strategies, and ITS researchers need to know the extent to which these needs are unmet. This research will: 1) develop a system to communicate information to potential implementors, 2) determine unmet research needs, and 3) develop a method for selecting PATH research projects to obtain the maximum public benefit.

Methodologies for Assessing the Impacts of ITS and Conventional Highway Improvements on Travel Behavior

Joy Dahlgren, PATH Headquarters; Mark Hansen, David Gillen, Institute of Transportation Studies, University of California, Berkeley

Fears that capacity-enhancing ITS projects will increase travel proportionally may hamper implementation of such projects. This research will utilize recent and current conventional highway-capacity improvements to develop and evaluate methods for assessing the effects of capacity improvements in general on number of trips, departure times, routes, and modes.

PATH Research



Preliminary Study of IVHS Policy Issues

Lamont C. Hempel, Thomas A. Horan, Claremont Graduate School

The purpose of this research is to review and assess key institutional and policy-related issues confronting the development and deployment of advanced transportation technologies in California and identify follow-on steps that could be taken to systematically address these "non-technical" issues.

Toward a Methodology for Planning of Intelligent Urban Transportation Systems

Adib Kanafani, Institute of Transportation Studies, University of California, Berkeley

Earlier work at PATH developed PLANiTS, a system of computer-aided tools for transportation planning in an ITS environment. PLANiTS permits agencies to explore alternative projects for a regional transportation plan. The purpose of the current work is to integrate PLANiTS into a networked environment, such as the world-wide web, together with such sources as data systems and citizen participation forums, to see whether the transportation planning process can be enhanced by using recent developments in information technology.

Traffic Management Centers

Computer Integrated Transportation: Organizational Design for Implementation of ITS and Intermodal TMC

Randolph Hall, Industrial & Systems Engineering, University of Southern California

The objective of this study is to identify the most effective means for California to fulfill the promise of ITS, within the framework of computer-integrated-transportation. This entails identification of the most effective role that the State can serve in working with both public and private organizations within an integrated transportation system.

Traffic Management Systems Performance Measurement

James H. Banks, Civil and Environmental Engineering, California State University, San Diego

This project will develop measures of effectiveness for Caltrans Traffic Management Centers and their major functional responsibilities (ramp metering, incident management, ATIS, etc.) and will provide plans for improving TMC data collection and data management systems in support of performance measurement.

Transportation Management Centers: Future Scope

Hong Lo, PATH Headquarters

TMCs are focal points for monitoring and operating transportation systems. The goal of this research is to describe significant future roles and configurations of TMCs in California, considering present capabilities, ongoing research and evolving transportation needs and technologies.



PATH Publications

PATH Publications

ATMIS—Advanced Traffic Management Information Systems

APTS—Advanced Public Transportation Systems

Assessment of IVHS-APTS Technology Impacts on Energy Consumption and Vehicle Emissions of Transit Bus Fleets

Sylvan C. Jolibois, Jr., Adib Kanafani

The results invite skepticism about the benefits of APTS technologies insofar as pollutant emissions and fuel consumption are concerned. Recommendations are made about how technologies and services that can attract travelers from auto to transit without increasing bus miles should be emphasized.

UCB-ITS-PRR-94-19 August 1994 20 pp \$5.00

Improving Transit Performance with Advanced Public Transportation System Technologies

Mark Hansen, Mohammad Qureshi, Daniel Rydzewski

Focuses on the attitudes and experiences of individual transit agency management, staff, and line personnel that are likely to determine their future choices with regard to APTS adoption and utilization. Proposes improvements to current adoption and utilization practices.

UCB-ITS-PRR-94-18 August 1994 121 pp \$15.00

Development of User Needs and Functional Requirements for a Real-Time Ridesharing System

Raghu Kowshik, John Gard, Jason Loo, Paul P. Jovanis, Ryuichi Kitamura

User needs are utilized to develop functional requirements for the proposed Real-Time Rideshare Matching system, and to identify services that should be provided by the system as well as interfaces to access the system.

UCB-ITS-PWP-93-22 December 1993 35 pp \$7.00

Evaluation of the Transit Information System in Southern California

Emmanuel Le Colletter, Youngbin Yim, Randolph Hall

Study of the effectiveness of the transit telephone information system on trip behavior at Metropolitan Transit Authority (MTA), from both the user's and the operator's perspective.

UCB-ITS-PRR-93-10 August 1993 80 pp \$10.00

Advanced Public Transportation Systems: A Taxonomy and Commercial Availability

Asad Khattak, Hisham Noeimi, Haitham Al-Deek, Randolph Hall

The main objectives of this study are to: 1) systematically classify new transit technologies and their impacts, 2) use

the classification structure for exploring availability of new transit technologies, and 3) introduce technology developers to the California Advanced Public Transportation System (CAPTS) program.

UCB-ITS-PRR-93-09 August 1993 95 pp \$12.00

ATIS—Advanced Traveler Information Systems

Concept of an Advanced Traveler Information System Testbed for the Bay Area: Research Issues

Asad J. Khattak, Haitham M. Al-Deek, Randolph W. Hall

The Bay Area ATIS testbed evaluation methodology is aimed at collecting, processing and enabling widespread dissemination of information on transportation condition and travel options. This paper discusses the TravInfo project and the Freeway Service Patrol evaluation project.

Tech Note 94-06 September 1994 35 pp \$7.00

Stated and Reported Route Diversion Behavior: Implications on the Benefits of ATIS

Asad Khattak, Adib Kanafani, Emmanuel Le Colletter

ATIS user benefits are estimated from a survey of commuting behavior undertaken in the San Francisco Bay Area in 1993. Both reported and stated response to unexpected congestion are used to determine the commuters who would directly benefit from qualitative, quantitative, predictive, and prescriptive ATIS information.

UCB-ITS-PRR-94-13 May 1994 38 pp \$7.00

Combined Traveler Behavior and System Performance Model with ATIS

Asad Khattak, Haitham Al-Deek, Paramsothy Thananjeyan

Unique features are: integration of traveler behavior and system performance in the context of ATIS, exploration of unsaturated and over-saturated conditions, and investigation of the possibility of congesting alternate routes as well as the issue of user equilibrium.

UCB-ITS-PRR-94-06 March 1994 55 pp \$7.00

Models of Commuter Information Use and Route Choice

Mohamed A. Abdel-Aty, Kenneth M. Vaughn, Ryuichi Kitamura, Paul P. Jovanis, Fred L. Mannering

Based on a 1992 computer-aided telephone interview survey of Los Angeles area morning commuters. Results showed that only 15.5% of the respondents reported that they don't always follow the same exact route to work.

UCB-ITS-PWP-93-21 November 1993 38 pp \$7.00

Custom Interface Builder Palettes for Advanced Driver Interface Rapid Prototyping*David W. Moore*

A brief introduction to four classes of software objects developed to help a user create and test interfaces using these objects in the Interface Builder application environment.

UCB-ITS-PWP-93-19 November 1993 11 pp \$5.00

Exploration of Driver Route Choice with Advanced Traveler Information Using Neural Network Concepts*Hai Yang, Ryuichi Kitamura, Paul P. Jovanis, Kenneth M. Vaughn, Mohammed A. Abdel-Aty, Prasuna DVG Reddy*

Results indicated that subjects made route choices based on their recent experiences and personal characteristics as well as the characteristics of the respective routes.

UCB-ITS-PRR-93-13 September 1993 28 pp \$5.00

Experimental Analysis and Modeling of Sequential Route Choice Under ATIS in a Simple Traffic Network*Kenneth M. Vaughn, Mohamed A. Abdel-Aty, Ryuichi Kitamura, Paul P. Jovanis, Hai Yang*

Results indicate that drivers can rapidly identify the accuracy level of information being provided and that they adjust their behavior accordingly.

UCB-ITS-PRR-93-12 September 1993 34 pp \$7.00

Behavioral Impacts of Recurring and Incident Congestion and Response to Advanced Traveler Information Systems in the Bay Area: An Overview*Asad J. Khattak*

Travelers' route, departure time and mode selection decisions in response to incident and recurring congestion were investigated through a survey of Bay Area automobile commuters.

UCB-ITS-PWP-93-12 September 1993 74 pp \$7.00

Impact of ATIS on Drivers' Decisions and Route Choice: A Literature Review*Mohamed A. Abdel-Aty, Kenneth M. Vaughn, Ryuichi Kitamura, Paul P. Jovanis*

Reviews the recent studies of drivers' behavior, and in particular their behavior when influenced by an Advanced Traveler Information System (ATIS).

UCB-ITS-PRR-93-11 September 1993 44 pp \$7.00

Collecting Road Traffic Data Using ALOHA Mobile Radio Channel*Jean-Paul M.G. Linnartz, D.P. Gamba*

Proposes a spectrum-efficient solution for transmitting link travel times from vehicles to a central infrastructure.

UCB-ITS-PWP-93-09 August 1993 21 pp \$5.00

Message Volumes for Two Examples of Automated Freeway*Anthony Hitchcock*

The volume of messages transmitted between vehicles, or between vehicles and the infrastructure, is calculated in order to estimate the demand of AVCS systems for frequency allocations.

UCB-ITS-PRR-93-01 March 1993 17 pp \$5.00

Role of Advanced Traveler Information Systems in Incident Management*H.M. Al-Deek*

Using an idealized traffic corridor and deterministic queuing methods, conditions under which route guidance information is useful are identified.

UCB-ITS-PRR-92-12 December 1992 154 pp \$17.00

Feasibility Study of Advanced Technology HOV Systems. Volume 3: Benefit Implications of Alternative Policies for Including HOV Lanes in Route Guidance Networks*T. Chira-Chavala, W.H. Lin*

Policy scenarios for including HOV lanes in dynamic route-guidance networks, when HOV lanes exist on the corridors.

UCB-ITS-PRR-92-05 December 1992 56 pp \$7.00

Bay Area ATIS Testbed Plan*A. Khattak, H. Al-Deek, Y.B. Yim, Randolph Hall*

The Bay Area ATIS (Advanced Traveler Information System) Testbed is a public/private partnership aimed at enabling wide-spread dissemination of real-time information on transportation conditions and travel options. This document presents the plan and procedures for conducting research within the Testbed.

UCB-ITS-PRR-92-01 September 1992 81 pp \$10.00

Expanding Usage of Cellular Phones: User Profile and Transportation Issues*Youngbin Yim, Adib Kanafani, Jean-Luc Ygnace*

Assessment of a mail survey of GTE Mobilnet customers in the San Francisco Bay Area conducted to assess the interrelationships between cellular communication and driver behavior.

UCB-ITS-PRR-91-19 December 1991 79 pp \$9.00

Electronic Toll-Collection Systems (ETC) User Survey*Youngbin Yim*

Summary of several surveys concerning the use of an electronic toll-collection system among San Francisco Bay Area motorists.

UCB-ITS-PRR-91-12 June 1991 110 pp \$12.00

Incident Management with Advanced Traveler Information Systems

Haitham Al-Deek, Adib Kanafani

A graphical queuing techniques model is utilized to define cases when ATIS is beneficial and cases when it is not, also to evaluate its benefits as measured by travel time savings. Benefits to relevant parameters are also analyzed.

UCB-ITS-PWP-91-05 June 1991 31 pp \$5.00

User Perceived Benefits with Navigation Systems

Herve Commeignes

Studies relative time savings between vehicles unequipped and equipped with route guidance and navigation systems, in particular, to what extent relative travel-time savings decrease as the percentage of equipped vehicles increases.

UCB-ITS-PWP-91-02 June 1991 44 pp \$7.00

Vehicle Navigation and Route Guidance Technologies: Push and Pull Factors Assessment

Jean-Luc Ygnace, Haitham Al-Deek, Paul Lavallee

Analyzes the different conditions in the US, Europe, and Japan.

UCB-ITS-PRR-90-02 May 1990 55 pp \$7.00

Some Theoretical Aspects of the Benefits of En-Route Vehicle Guidance (ERVG)

Haitham M. Al-Deek, Adib Kanafani

It is found that travel time savings of the order of 3-4% can be achieved from route guidance. Benefits are quite sensitive to city street speed. Route guidance benefits can be enhanced if information is customized to motorists on the basis of their origins and destinations.

UCB-ITS-PRR-89-02 August 1989 51 pp \$11.00

Potential Benefits of In-Vehicle Information Systems (IVIS): Demand and Incident Sensitivity Analysis

Haitham Al-Deek, Adolf May

The objective of this research is to conduct traffic demand and incident sensitivity analysis of benefits of IVIS by studying variations in demand levels, incident severity, and incident location.

UCB-ITS-PRR-89-01 May 1989 88 pp \$8.00

Potential Benefits of In-Vehicle Information Systems in a Real Life Freeway Corridor Under Recurring and Incident-Induced Congestion

Haitham Al-Deek, Michael Martello, Adolf May, Wiley Sanders

This report presents use of the FREQ8PC program to simulate traffic on the Santa Monica Freeway corridor.

UCB-ITS-PRR-88-02 July 1988 205 pp \$23.00

Towards a Technology Assessment of Highway Navigation and Route Guidance

Adib Kanafani

This technology has reached an advanced stage and is on the market in some forms. Needed is an assessment of driver response and network behavior to evaluate technical requirements and limitations.

UCB-ITS-PWP-87-06 December 1987 15 pp \$5.00

Research Plan for Highway Vehicle Navigation Technology

Geoffrey D. Gosling

Addresses navigation, communication, and control technology, benefits of improved vehicle navigation, system requirements, and design and implementation issues. Six near-term and ten follow-on projects are described.

UCB-ITS-PWP-87-01 December 1987 51 pp \$7.00

ATMS—Advanced Traffic Management Systems

Investigating Intelligent Transportation Systems Strategies on the Santa Monica Freeway Corridor: Technical Appendix

Vinton W. Bacon Jr., John R. Windover, Adolf D. May

Appendices for PRR-95-38

UCB-ITS-PRR-95-39 November 1995 \$35.00

Investigating Intelligent Transportation Systems Strategies on the Santa Monica Freeway Corridor

Vinton W. Bacon Jr., John R. Windover, Adolf D. May

Describes a multi-year research effort, involving a massive data collection effort, to simulate the Corridor using the INTEGRATION computer simulation model and to investigate potential benefits of ITS. Investigations indicate that ATIS benefits increase significantly with incident severity and significantly decrease with distorted information.

UCB-ITS-PRR-95-38 November 1995 200 pp \$30.00

Vehicle as Probes

Kumud K. Sanwal, Jean Walrand

Discusses the use of vehicles moving in traffic as probes that can report data on their speeds, locations, or travel times which can be used by an algorithm to update estimates of traffic state and make predictions for the future.

UCB-ITS-PWP-95-11 August 1995 26 pp \$10.00

Freeway Service Patrol (FSP) 1.1: The Analysis Software for the FSP Project.

Karl Petty

Reference manual for the fsp program, a software tool used to interrogate the data collected during the Freeway Service Patrol Evaluation Project, and the xfsp program, a graphical user interface to the fsp program.

UCB-ITS-PRR-95-20 June 1995 271 pp \$35.00

PATH Publications

Variable Message Signs and Link Flow Evaluation: A Case Study of the Paris Region*Youngbin Yim, Jean-Luc Ygnace*

Preliminary investigation of the effectiveness of the SIRIUS system in traffic management. Systeme d'Information Routiere Intelligible aux Usagers is the largest urban field operational test of an advanced traveler information and automated traffic management system in Europe.

UCB-ITS-PWP-95-05 May 1995 46 pp \$10.00

Machine Vision Based Surveillance System for California Roads*J. Malik, S. Russell*

Describes the successful combination of a low-level, vision-based surveillance system with a high-level, symbolic reasoner based on dynamic belief networks. Discusses the key tasks of the vision and reasoning components as well as their integration into a working prototype.

UCB-ITS-PRR-95-06 March 1995 22 pp \$5.00

Freeway Service Patrol Evaluation*Alexander Skabardonis, Hisham Noeimi, Karl Petty, Dan Rydzewski, Pravin P. Varaiya, Haitham Al-Deek*

Presents the findings of a comprehensive evaluation of the freeway service patrol (FSP) program on a specific freeway section in the San Francisco Bay Area. Data were collected during the peak periods on a 1 mile section of the I-880 freeway in the City of Hayward, Alameda County, California.

UCB-ITS-PRR-95-05 February 1995 140 pp \$20.00

Simple Time Sequential Procedure for Predicting**Freeway Incident Duration***Asad Khattak, Joseph L. Schofer, Mu-Han Wang*

The authors first develop an understanding of factors that influence incident duration. A series of truncated regression models is used to predict incident duration. The implications of this simple methodology for incident duration prediction are discussed.

UCB-ITS-PRR-94-26 November 1994 42 pp \$7.00

Organizing for IVHS: Computer Integration Transportation. Phase 1: Results for Arterial and Highway Transportation Management Centers*Randolph W. Hall, Hong K. Lo, Erik Ming*

This study finds that four factors have profound implications for ITS implementation and research: time-frame, linking information to actions, broadcast orientation, and embracement of new technologies.

UCB-ITS-PRR-94-24 November 1994 70 pp \$9.00

Incidents and Interventions on Freeways*Benjamin Heydecker*

Focuses on spatio-temporal aspects of congestion caused by an incident and how they can be alleviated by traffic management intervention. A kinematic wave model of traffic is applied to investigate the issues of congestion.

UCB-ITS-PRR-94-05 February 1994 39 pp \$7.00

Robust Multiple Car Tracking with Occlusion Reasoning*Dieter Koller, Joseph Weber, Jitendra Malik*

A new approach for detecting and tracking vehicles in road traffic scenes. High accuracy and reliability are obtained by using an explicit occlusion reasoning step, employing a contour tracker based on intensity and motion boundaries.

UCB-ITS-PWP-94-01 January 1994 29 pp \$5.00

California Transportation Management Centers — Part 1: Assessment of Existing Capabilities*Hong K. Lo, Randolph W. Hall, John R. Windover*

This document includes a brief overview of TMC development efforts, and results of in-depth interviews with personnel at all seven Caltrans TMCs and three city TMCs.

UCB-ITS-PWP-93-17 December 1993 55 pp \$7.00

Symbolic Traffic Scene Analysis Using Dynamic Belief Networks*Tim Hagan, Gary Ogasawara, and Stuart Russell*

Describes traffic-scene analysis from the low-level processing of a traffic scene to its high-level description. Explains what dynamic belief networks are and some issues involved in using them for scene analysis.

TECH MEMO-93-08 November 1993 6 pp \$5.00

Analysis of Arterial Street Data from the ATISAC System*Vinton W. Bacon, Jr., Adolf D. May*

This study is part of an effort to simulate the Santa Monica Freeway Corridor in Los Angeles using the INTEGRATION model.

UCB-ITS-PWP-93-11 August 1993 67 pp \$8.00

Freeway Detector Data Analysis for Simulation of the Santa Monica Freeway—Summary Report*Loren D. Bloomberg, Adolf D. May*

Develops on/off ramp counts as input to a synthetic origin/destination model; strategies for synthesizing data from stations where current detector data are unavailable are also considered.

UCB-ITS-PWP-93-10 August 1993 44 pp \$7.00

Freeway Detector Data Analysis for Simulation of the Santa Monica Freeway—Initial Investigations

Loren D. Bloomberg, Vinton W. Bacon, Jr., Adolf D. May

This analysis of vehicle detector data on the Santa Monica Freeway found that approximately 32 percent of the main-line freeway detectors appeared to give reasonable results.

UCB-ITS-PWP-93-01 August 1993 31 pp \$7.00

Robust Computation of Optical Flow in a Multi-Scale Differential Framework

Joseph Weber, Jitendra Malik

This approach to motion detection can be part of a real-time vision application system in which linear filters provide a basis for visual tasks such as passive ranging and moving object detection.

UCB-ITS-PWP-93-04 July 1993 19 pp \$5.00

Neural Network Models for Automated Detection of Non-Recurring Congestion

Stephen G. Ritchie, Ruey L. Cheu

Spatial and temporal traffic patterns are recognized and classified by an artificial neural network.

UCB-ITS-PRR-93-05 June 1993 161 pp \$18.00

Control Strategies and Route Guidance in Signal Controlled Networks

Alexander Skabardonis

Control and timing strategies to handle diverted traffic from the freeways to surface streets were developed and tested through simulation on real-life networks.

UCB-ITS-PRR-91-20 August 1991 46 pp \$7.00

AVCS/AHS—Advanced Vehicle Control Systems and Automated Highway Systems

AHS Architecture

Vehicle-Based Control Computer Systems

David M. Auslander

Describes a design and implementation methodology for real-time software suitable for control of mechanical systems such as vehicles. Explores methods for estimating velocity when the even rate from a digital encoder is lower than the controller's sample time.

UCB-ITS-PRR-95-03 January 1995 56 pp \$7.00

Communication Architecture for IVHS

S. Streisand, J. Walrand

This paper documents the development of a layered architecture based on the OSI 7-layer reference model.

UCB-ITS-PRR-92-10 September 1992 76 pp \$9.00

Real Time Software Requirements for Vehicle Control Systems

David M. Auslander, An-Chyau Huang

This memorandum is intended as a means of unifying the software development among various PATH research groups, and, as such, as a focus for continuing discussion rather than a "solution."

TECH MEMO-92-02 August 1992 21 pp \$5.00

Sketch of an IVHS Systems Architecture

Pravin Varaiya, Steven Shladover

Presents a sketch of a system architecture for the control and management tasks of an intelligent vehicle/highway system (IVHS)

UCB-ITS-PRR-91-03 October 1990 33 pp \$5.00

AHS—Degraded Modes of Operation

Fault Detection and Identification with Application to Advanced Vehicle Control Systems

Randal K. Douglas, Jason L. Speyer, D. Lewis Mingori, Robert H. Chen, Durga P. Malladi, Walter H. Chung

A preliminary design of a health monitoring system for automated vehicles is developed and results of tests in a high-fidelity nonlinear simulation are reported.

UCB-ITS-PRR-95-26 August 1995 88 pp \$15.00

Optimization Tools for Automated Vehicle Systems

Zvi Shiller

Focuses on computing time-optimal maneuvers to develop strategies for emergency maneuvers and establishing a vehicle's performance envelope. The problem of emergency maneuvers is addressed in the context of time optimal control.

UCB-ITS-PWP-95-10 July 1995 30 pp \$10.00

Design of an Extended Architecture for Degraded Modes of Operation of AHS

John Lygeros, Datta N. Godbole, Mireille E. Broucke

Proposes a hierarchical control architecture for dealing with faults and adverse environmental conditions on an Automated Highway System (AHS). The extended control strategies needed by the supervisors of each layer of the hierarchy are outlined, and in certain cases, examples are given of their detailed operation.

UCB-ITS-PWP-95-03 April 1995 31 pp \$10.00

Design of Decentralized Adaptive Controllers for a Class of Interconnected Nonlinear Dynamical Systems: Part 1

Shahab Sheikholeslam, Charles A. Desoer

We consider the class of interconnected nonlinear dynamical systems suggested by the problem of longitudinal

PATH Publications

control of a platoon of vehicles on automated highways and propose a control scheme in which these deviations are bounded independent of parameter errors.

TECH MEMO-92-01 February 1992 37 pp \$7.00

PATH Publications

AHS General System Issues

Staggered-Diamond Design for Automated/Manual-HOV Highway-to-Highway Interchange

H.-S. Jacob Tsao

Proposes a staggered-diamond design requiring only four separate structures, each supporting two-way traffic, for the eight additional connector ramps for AHS that requires. Discusses the constraints of this design on the conceptual design and evolution of AHS. The proposed design increases the feasibility of a freeway shuttle van service, proposed by Tsao as the initial AHS deployment target.

UCB-ITS-PRR-95-31 September 1995 31 pp \$10.00

Traffic Control for Automated Highway Systems: A Conceptual Framework

H.-S. Jacob Tsao

Since vehicle movement plans are generated by various controllers in the AHS, planned vehicle moves have the potential of conflicting and interfering with one another. This paper defines all permissible vehicle movements in terms of "building block" moves, then identifies and defines planning and movement functions required for supporting desired control features.

UCB-ITS-PRR-95-30 September 1995 39 pp \$10.00

Models, Simulation, and Performance of Fully Automated Highways

Pravin Varaiya

A brief reconstruction of the history of the AHS concept and a summary of the principal findings of AHS performance is followed by an overview of the simulation program SmartPath. An outline of the current work on SmartPath and plans for the immediate future are given.

UCB-ITS-PRR-94-21 October 1994 18 pp \$5.00

Comparale Systems Analysis of San Francisco's BART: Lessons for Automated Highway Systems

Mark D. Hickman

Investigates both technical (safety, reliability, and maintenance) and non-technical (political pressure and public confidence) issues.

UCB-ITS-PWP-94-17 December 1994 28 pp \$5.00

Functional Architecture for Automated Highway Traffic Planning

H.-S. Jacob Tsao

This report defines an architecture for Automated Highway System (AHS) capacity-optimizing traffic planning functions.

It identifies major traffic planning functions useful for optimizing the capacity of one or more major AHS operating scenarios and organizes them in a robust architecture that is modular, hierarchical, complete, expandable and integratable.

UCB-ITS-PRR-94-16 July 1994 17 pp \$5.00

Conceptual Approach for Developing and Analyzing Alternate Evolutionary Deployment Strategies for Intelligent Vehicle/Highway Systems

Rokaya Al-Ayat, Randolph Hall

Defines an evolutionary deployment sequence, identifies baseline assumptions, and presents strategies for achieving success.

UCB-ITS-PWP-94-05 March 1994 47 pp \$7.00

AHS (Automated Highway System) Deployment: A Preliminary Assessment of Uncertainties

Randolph W. Hall, H.-S. Jacob Tsao

Seven issues are addressed, concerning whether: 1) People use AHS, 2) Auto makers manufacture equipped vehicles, 3) Government builds AHS roadways, 4) Highways can evolve, 5) Interest groups do not obstruct, 6) Performance is adequate, and 7) Technology is feasible.

UCB-ITS-PWP-94-02 February 1994 19 pp \$5.00

Consumer Demand for Automated Private Travel: Extrapolations from Vanpool Users' Experience

Nirupa Bonanno, Daniel Sperling, Kenneth S. Kurani

A focus group of existing vanpoolers was presented with the choice of driving alone or commuting with others.

UCB-ITS-PRR-93-17 November 1993 71 pp \$9.00

Continuing Systems-level Evaluation of Automated Urban Freeways: Year Three

Robert A. Johnston, Raju Ceerla

This study demonstrated the travel and emissions impacts of urban freeway automation scenarios and compared these to travel demand reduction scenarios, such as travel pricing and land use intensification. The Sacramento regional travel demand model set was used.

UCB-ITS-PRR-93-15 October 1993 91 pp \$10.00

Longitudinal and Lateral Throughput on an Idealized Highway

Randolph W. Hall

Uses deterministic approximations to model highway throughput. The model identifies conditions under which lane changes have an appreciable effect on capacity, assuming certain idealized conditions are met.

UCB-ITS-PWP-93-15 October 1993 21 pp \$5.00

Design Options for Operation of Fully Automated Highway Systems

H-S. Jacob Tsao, Randolph W. Hall, Steven E. Shladover

Proposes six fully automated AHS operating scenarios featuring variations in three design options critical to the human factors of AHS operations.

TECH MEMO-93-03 February 1993 37 pp \$5.00

Smart Cars on Smart Roads: Problems of Control

Pravin Varaiya

Outlines key features of one highly automated IVHS system, shows how core driver decisions are improved, proposes a basic IVHS control system architecture, and offers a design of some control subsystems.

TECH MEMO-91-05 December 1991 30 pp \$5.00

Time Benefits of New Transportation Technologies: The Case of Highway Automation

Randolph W. Hall

Components of travel time are introduced and compared. A series of highway automation concepts is created, and the time benefits of each are discussed.

UCB-ITS-PWP-91-04 June 1991 48 pp \$7.00

AHS Safety

Driving Safely in Smart Cars

Anuj Puri, Pravin Varaiya

Considers the issue of safety in Automated Vehicle Highway Systems (AVHS) and proposes an approach for proving that a system is safe. The authors contend that the problem of checking whether physical controllers in the vehicles satisfy safety constraints is equivalent to an optimal control problem.

UCB-ITS-PRR-95-24 July 1995 17 pp \$5.00

Configuration and Maneuvers in Safety-Consciously Designed AHS Configuration

Anthony Hitchcock

Describes a configuration and operating principles for an Automated Highway System that is believed to have advantages from a safety viewpoint. The scheme requires that vehicles change lanes directly from platoon to platoon, and that entry and exit be made also without platoons merging or splitting on the automated lanes.

UCB-ITS-PWP-95-02 June 1995 20 pp \$5.00

Layout, Design and Operation of a Safe Automated Highway System

Anthony Hitchcock

For all accident types, there is one system which has casualties per incident no greater than 10% of its nearest rivals. This "preferred" system is described, and the predicted casualty rate results are quoted and discussed. If

reliability of the control systems is sufficient, the advantages of the preferred system become unimportant.

UCB-ITS-PRR-95-11 April 1995 26 pp \$10.00

Intelligent Vehicle Highway System Safety: Multiple Collisions in Automated Highway Systems

Anthony Hitchcock

Compares casualty rates per failure on an automated highway system (AHS) according to the longitudinal control configuration used. The model used permits evaluation of the consequences of a failure, allowing for the multiple collisions that usually ensue.

UCB-ITS-PRR-95-10 April 1995 31 pp \$10.00

Entry to and Exit from a Safety-Consciously Designed AHS Configuration

Anthony Hitchcock

This paper proposes entry and exit maneuvers compatible with the automated highway system described in the author's paper "Configuration and Maneuvers in an Automated Highway System designed for Optimum Safety."

Tech Note 95-04 April 1995 8 pp \$5.00

Coefficients of Friction and Automated Freeways

Anthony Hitchcock

Sets out some simple facts about the effects of the interaction between tires and the road insofar as it affects braking and forward acceleration. Attention is drawn to how AHS carriageways may wear differently from those on present-day freeways, and possible effects on braking capability.

Tech Note 94-01 February 1994 6 pp \$5.00

Assessing the Safety Benefits of Automated Freeways

Mohammed Anwar, Paul P. Jovanis

This research is aimed at the identification of all types of accidents that have occurred on freeways that may affect vehicle movement in the assumed automated left lane.

UCB-ITS-PRR-93-29 December 1993 59 pp \$7.00

Casualties in Accidents Occurring During Split and Merger Maneuvers

Anthony Hitchcock

This paper explores conditions of reliability in split and merge maneuvers as part of an Automated Highway System (AHS). It also explores "follower's collisions" in an AHS.

TECH MEMO-93-09 November 1993 13 pp \$5.00

Example of Quantitative Evaluation of AVCS Safety

Anthony Hitchcock

A method for expressing in absolute terms the effect on safety of various features in the design of an AVCS system.

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Figures can be calculated for various degrees of injury, and variations in assumptions.

TECH MEMO-93-04 August 1993 8 pp \$5.00

Probabilistic Model and a Software Tool for AVCS Longitudinal Collision/Safety Analysis

H.-S. Tsao, Randolph Hall

We use this model to compare the safety consequences associated with the platooning and "free-agent" vehicle-following rules.

UCB-ITS-PWP-93-02 June 1993 23 pp \$5.00

Specification of an Automated Freeway with Vehicle-Borne Intelligence

Anthony Hitchcock

Derives a technique of safety analysis for an AHS by applying a procedure called fault tree analysis. The safety criterion used is that two or more simultaneous faults must occur independently before the hazards can arise.

UCB-ITS-PRR-92-18 December 1992 142 pp \$14.00

Fault-Tree Analysis of an Automated Freeway with Vehicle-Borne Intelligence

Anthony Hitchcock

Analysis of an automated freeway characterized by extreme emphasis on vehicle-borne intelligence, and by the presence of a multiplicity of automated lanes.

UCB-ITS-PRR-92-15 December 1992 44 pp \$7.00

Methods of Analysis of IVHS Safety

Anthony Hitchcock

Final report of a PATH project on developing and demonstrating methods by which the safety of Intelligent Vehicle Highway Systems (IVHS) can be assured, assessed and evaluated.

UCB-ITS-PRR-92-14 December 1992 106 pp \$12.00

Methods of Analysis of IVHS Safety - Executive Summary

Anthony Hitchcock

Management and policy issues are briefly discussed in conclusion.

UCB-ITS-PRR-92-13 December 1992 11 pp \$5.00

Use of NASS Data for Evaluation of AVCS Devices

Anthony Hitchcock

In general, NASS raw data are useful for evaluation of AVCS whenever a driver's choices are limited to keeping a straight course at an appropriate speed.

UCB-ITS-PRR-91-08 July 1991 12 pp \$5.00

Fault-Tree Analysis of a First Example Automated Freeway

Anthony Hitchcock

How conformity to safety criteria can be demonstrated by fault-tree analysis.

UCB-ITS-PRR-91-14 June 1991 51 pp \$7.00

First Example Specification of an Automated Freeway

Anthony Hitchcock

Specification for an automated freeway in a fully formal manner. A series of safety analyses have been carried out on the specification.

UCB-ITS-PRR-91-13 June 1991 146 pp \$16.00

Notes From a Talk on Standards and IVHS Safety

Anthony Hitchcock

The author focuses on three distinct themes relevant to IVHS design and evaluation: 1) hazard analysis and the safety-critical subsystem; 2) design, verification, and validation of safety-critical software, and, 3) configuration management.

UCB-ITS-PWP-91-03 May 1991 11 pp \$5.00

AHS Sensors

Intelligent Sensor Validation and Sensor Fusion for Reliability and Safety Enhancement in Vehicle Control

Alice Agogino, Kai Goebel, Satnam Alag

An evaluation of methods for validation and fusion of sensor readings obtained from multiple sensors, to be used in tracking automated vehicles and avoidance of obstacles in a vehicle's path. Tests were conducted under dynamic and static test conditions, as well as under vibrations.

UCB-ITS-PRR-95-40 November 1995 56 pp \$15.00

Coordination and Link Layer Control

AVHS Link Layer Controller for Traffic Flow Stabilization

Perry Li, Roberto Horowitz, Luis Alvarez, Jonathan Frankel, Anne M. Robertson

Controls for the link layer in the AVHS hierarchy proposed in PATH are developed. The control laws obtained are suited for implementation in the lower levels of the AVHS control hierarchy. Simulation results are also presented.

Tech Note 95-07 November 1995 43 pp \$15.00

Macroscopic Roadway Traffic Controller Design

C.C. Chien, Y. Zhang, A. Stotsky, S.R. Dharmasena, P. Ioannou

A roadway controller is designed, analyzed and simulated for a single automated highway lane that achieves desired traffic densities along the lane. Simulation results are used to illustrate the controller's effectiveness and the significant benefits AHS may bring to traffic flow.

UCB-ITS-PRR-95-28 August 1995 29 pp \$10.00

Hierarchical Hybrid Control of Automated Highway Systems

Dattaprabodh Narhar Godbole

Describes individual layers of the hierarchical control architecture for platooning, the design of a regulation layer feedback controller for platoon leaders, an interface between this feedback controller and the discrete event coordination layer, and an analysis of the combined hybrid system using a dedicated simulation tool.

UCB-ITS-PRR-95-08 March 1995 147 pp \$20.00

Robust Platoon Maneuvers for AVHS

Jonathan Frankel, Luis Alvarez, Roberto Horowitz, Perry Li

Presents new control strategies for the three longitudinal maneuvers: merge, split and decelerate to change lanes. A merge maneuver in which the velocity of the trail platoon never exceeds the maximum safe velocity is examined, and the control approach is applied to the other maneuvers.

Tech Note 94-09 November 1994 37 pp \$7.00

Design of Platoon Maneuver Protocols for IVHS

Ann Hsu, Farokh Eskafi, Sonia Sachs, Pravin Varaiya

We consider the design of the controllers for platoons of up to twenty closely spaced vehicles under automatic control.

UCB-ITS-PRR-91-06 April 1991 60 pp \$7.00

Two Proposals to Improve Freeway Traffic Flow

Ufuk Karaaslan, Pravin Varaiya, Jean Walrand

A plausible model of platoons in which the lead car is manually driven indicates that for an average platoon size of 10, freeway capacity increases by a factor of four.

UCB-ITS-PRR-90-06 April 1990 22 pp \$5.00

Integrated Lateral and Longitudinal Control

Fuzzy Throttle and Brake Control for Platoons of Smart Cars

Hyun Mun Kim, Julie Dickerson, Bart Kosko

The authors designed and tested a throttle-only fuzzy system on a validated car model and then with a real car on highway I-15 in California. They then designed a throttle and brake controller.

UCB-ITS-PRR-95-42 December 1995 46 pp \$10.00

Integrated Maneuvering Control for Automated Highway Systems Based on a Magnetic Reference Sensing System

Masayoshi Tomizuka, J. Karl Hedrick, Hung Pham

A model of a combined longitudinal and lateral eighteen-state vehicle chassis, engine, and drive train is developed

and validated against existing longitudinal-only and lateral-only vehicle models. The full-size model is simplified to a three-state model to facilitate controller design.

UCB-ITS-PRR-95-12 April 1995 57 pp \$15.00

Combined Longitudinal and Lateral Control of a Platoon of Vehicles: A System Level Study

Shahab Sheikholeslam, Charles A. Desoer

The authors propose nonlinear control laws for a platoon of non-identical vehicles accelerating on a curved lane of highway. These laws are based on nonlinear models of vehicles' combined longitudinal and lateral dynamics.

TECH MEMO-91-03 September 1991 28 pp \$5.00

Lateral Control

Machine Vision Based System for Guiding Lane-Change Maneuvers. Final Report

Jitendra Malik, Dieter Koller, Tuan Luong

A new approach for vision based longitudinal and lateral vehicle control making extensive use of binocular stereopsis. A known camera geometry with respect to the locally planar road is used to map images of the road plane in two camera views into alignment. A disparity then indicates an object not lying in the road plane and hence a potential obstacle.

UCB-ITS-PRR-95-34 October 1995 47 pp \$10.00

Fuzzy Logic Control for Lane Change Maneuvers in Lateral Vehicle Guidance

Thomas Hessburg, Masayoshi Tomizuka

Investigates the feasibility of a fuzzy logic control algorithm for lateral control in a maneuver that takes a vehicle from lane following control in one lane to lane following control in an adjacent lane. The only sensor used for feedback is a lateral accelerometer.

UCB-ITS-PWP-95-13 October 1995 11 pp \$5.00

Adaptation Method for Fuzzy Logic Controllers in Lateral Vehicle Guidance

Thomas Hessburg, Masayoshi Tomizuka

A formulation is made for a model reference adaptive fuzzy logic control (MRAFLC) algorithm and applied to automatic steering control of a vehicle. The purpose is to design a fuzzy logic controller that addresses changes in operating conditions, including vehicle speed and road surface conditions, in the controller.

UCB-ITS-PRR-95-21 June 1995 50 pp \$10.00

Vehicle Lane Change Maneuver in Automated Highway Systems

Wonshik Chee, Masayoshi Tomizuka

Lane change maneuvers for an AHS are investigated as a tracking problem with respect to the virtual desired trajec-

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tory (VDT). The two main issues discussed are: 1) design of virtual desired trajectory and 2) design of control algorithms.
UCB-ITS-PRR-94-22 October 1994 37 pp \$7.00

Fault Detection and Tolerant Control for Lateral Guidance of Vehicles in Automated Highways

Satyajit Neelkanth Patwardhan

The main problems addressed are tire burst, sensor fault detection, and slip angle control. Tire burst and sensor faults are important failure modes for automated highways, whereas the slip angle control problem is important during maneuvers to enhance vehicle safety.

UCB-ITS-PRR-94-17 August 1994 130 pp \$15.00

Advances in Fuzzy Logic Control for Lateral Vehicle Guidance

Thomas Hessburg, Masayoshi Tomizuka

The most recent fuzzy logic controller (FLC), with a rule base derived from heuristics, is a good choice for lateral guidance in lane following, where the objective is to track the center of a lane with smooth ride quality under a range of varying operating conditions such as vehicle speed, wind gusts, and road conditions.

UCB-ITS-PWP-94-04 March 1994 29 pp \$5.00

Experimental Results of Fuzzy Logic Control for Lateral Vehicle Guidance

Thomas Hessburg, Huei Peng, Wei-Bin Zhang, Alan Arai, Masayoshi Tomizuka

A fuzzy logic controller (FLC) is designed and implemented in real time on a Toyota Celica test vehicle, automatically following a multiple curved track using discrete magnetic markers as a lateral error reference system. Results are compared to tests using the frequency shaped linear quadratic (FSLQ) controller with preview control.

UCB-ITS-PRR-94-03 February 1994 5 pp \$7.00

Feasibility Study of Advanced Technology HOV Systems. Volume 4: Implementation of Lateral Control Systems in Transitways

T. Chira-Chavala, W-B. Zhang, J. Walker, F. Javanel, L. Demsetz

Incremental systems for implementation in existing transitways, potential safety and capacity impacts of these systems, and human-factor issues relevant for the implementation of these systems.

UCB-ITS-PRR-92-06 December 1992 56 pp \$7.00

Experimental Automatic Lateral Control System for an Automobile

Huei Peng, Wei-Bin Zhang, Alan Arai, Ye Lin, Thomas Hessburg, Peter Devlin, Masayoshi Tomizuka, Steven Shladover

The project included a discrete roadway reference system, on-vehicle magnetic sensing system, a computer control system, and a hydraulic actuator.

UCB-ITS-PRR-92-11 November 1992 148 pp \$16.00

Theoretical and Empirical Analysis of PATH Magnetic Lane Tracking for the Intelligent Vehicle Highway System

Angus Andrews, Rockwell International Science Center

Characterizes statistical performance of the magnetic nails concept for estimating the positions of vehicles within their marked lanes. Presents a mathematical model for sensor noise due to distortions of the earth's field by patterns of ferrous reinforcing bars in the pavement.

UCB-ITS-PRR-92-09 August 1992 94 pp \$11.00

Fuzzy Rule-Based Controller for Automotive Vehicle Guidance

Thomas Hessburg, Masayoshi Tomizuka

Fuzzy rules, based on human drivers' experiences, are developed to track the center of a lane in the presence of external disturbances and over a range of vehicle operating conditions.

UCB-ITS-PRR-91-18 August 1991 20 pp \$5.00

Experimental Study on Lateral Control of a Vehicle

Thomas Hessburg, Huei Peng, Masayoshi Tomizuka, Wei-Bin Zhang

Results demonstrate the feasibility of proposed discrete magnetic marker reference/sensing system. Performance and limitations of a PID/feed-forward controller are also investigated.

UCB-ITS-PRR-91-17 August 1991 13 pp \$5.00

Optimal Preview Control for Vehicle Lateral Guidance

Huei Peng, Masayoshi Tomizuka

The continuous time deterministic optimal preview control algorithm is applied to lateral guidance of a vehicle for an automated highway.

UCB-ITS-PRR-91-16 August 1991 27 pp \$5.00

Lateral Control of Front-Wheel-Steering Rubber-Tire Vehicles

Huei Peng, Masayoshi Tomizuka

The performance of lateral feedback and feed-forward controllers is evaluated on a complex model, which includes motions in all six directions (longitudinal, lateral, vertical, roll, pitch, and yaw).

UCB-ITS-PRR-90-05 July 1990 45 pp \$7.00

Lateral Guidance Systems Requirements Definition

Robert E. Parsons, Wei-Bin Zhang

Presents a definition of PATH lateral guidance system requirements, followed by a discussion of different sensor systems (reference, passive reference, radar and acoustic).

UCB-ITS-PRR-88-01 August 1988 18 pp \$5.00

Longitudinal Control

Longitudinal Control Development for IVHS Fully Automated and Semi-Automated Systems: Phase II

J.K. Hedrick, J.C. Gerdes, D.B. Maciuga, D. Swaroop, V. Garg

Addresses the braking controller design issues, effects of braking on IVHS lane capacity, performance of platoons with various information structures, and fault detection filter design for automated vehicle control systems. (AVCS).

UCB-ITS-PRR-96-01 January 1996 126 pp \$20.00

Fuzzy Traffic Density Homogenizer for Automated Highway Systems

C.C. Chien, P. Ioannou, C.K. Chu

Proposes a fuzzy traffic density homogenizer to alleviate or avoid congestion by soothing the traffic density distribution profile over the freeway lanes.

UCB-ITS-PRR-95-44 December 1995 20 pp \$10.00

Modeling and Control Design for a Computer Controlled Brake System

H. Rasa, Z. Xu, P. Ioannou, B. Yang

Simulation results show that the proposed controller guarantees no overshoot and zero steady state error for step inputs. Tests of the controller using an experimental bench setup demonstrates its effectiveness in meeting the performance requirements.

UCB-ITS-PRR-95-37 November 1995 \$10.00

Adaptive Vehicle Traction Control

Hyeoncheol Lee, Masayoshi Tomizuka

Presents two different control algorithms for adaptive vehicle traction control, which includes wheel slip control, optimal time control, anti-spin acceleration and anti-skid control, and longitudinal platoon control. The two control algorithms are based, respectively, on adaptive fuzzy logic control and sliding mode control, with on-line road condition estimation.

UCB-ITS-PRR-95-32 September 1995 73 pp \$15.00

Longitudinal State Estimation for a Four-Vehicle Platoon

A.W. Merz

Dynamic equations and data are used for finding the estimates and root means squared errors in the estimated of the states for each vehicle. Several additional parameters require numerical specification, including data and process noise levels.

UCB-ITS-PRR-95-27 August 1995 63 pp \$15.00

Longitudinal Control – Phase 1

Kwang Soo Chang

Assesses the feasibility of vehicle-follower control, though traffic platoon control, with high accuracy and good ride quality, using a Doppler radar as the primary sensor.

UCB-ITS-PRR-95-22 August 1995 105 pp \$20.00

Integrated Maneuvering Control Design and Experiments: Phase 1

J. Karl Hedrick, Pravin Varaiya, V.K. Narendran, Sei-Bum Choi

Addresses the issues of vehicle control during transition maneuvers in Intelligent Vehicle Highway Systems. Transition maneuvers include automatic lane change of vehicles and merging and splitting of platoons of vehicles in the automated highway system. Also addresses issues involved in implementation of longitudinal control laws for vehicle control.

UCB-ITS-PRR-95-15 May 1995 66 pp \$15.00

Fuzzy Logic Traction Controllers and Their Effect on Longitudinal Vehicle Platoon Systems

M. Bauer, Masayoshi Tomizuka

A fuzzy logic approach is appealing for traction control because of the non-linearities and time-varying uncertainties in traction control systems. One fuzzy controller estimates the "peak slip" corresponding to the maximum tire-road adhesion coefficient and regulates wheel slip at that value. Another regulates wheel slip at any desired value.

UCB-ITS-PRR-95-14 May 1995 39 pp \$10.00

Longitudinal Control Development for IVHS Fully Automated and Semi-Automated Systems - Phase I

J. Karl Hedrick, D.H. McMahon, D. Swaroop, V. Garg, J.C. Gerdes, D.B. Maciuga, T.T. Blackman, P.P. Yip

Addresses some of the important longitudinal vehicle modeling and control issues of AVCS, such as brake dynamic model development and validation, decentralized longitudinal control algorithms that guarantee the stability of the entire platoon, and fault detection and isolation in the longitudinal vehicle dynamics of controlled vehicles.

UCB-ITS-PRR-95-04 January 1995 128 pp \$14.00

Handbook for Intervehicle Spacing in Vehicle Following

Y. Sun, P. Ioannou

A general worst-case stopping scenario for vehicle following is used to develop algorithms for generating the minimum safety spacing (MSS) for collision-free vehicle following. These algorithms are used to study the effects of vehicle characteristics and other parameters on the value of the MSS.

UCB-ITS-PRR-95-01 January 1995 41 pp \$7.00

Vehicle Longitudinal Control Using Discrete Markers

David W. Love, Masayoshi Tomizuka

Develops a hybrid observer as a method of estimating position and velocity of a vehicle when the primary input is a series of discrete magnetic markers. A Proportional-Integral-Derivative (PID) controller acting on error signals from the hybrid observer is also developed and simulated.

UCB-ITS-PRR-94-28 December 1994 \$7.00

Brake Dynamics Effect on IVHS Lane Capacity*Dragos B. Maciuca*

An assessment of the effects of brake system dynamics and intervehicle communication delays (microscopic characteristics) on the capacity of an automated highway system (macroscopic characteristics). Recommendations are made about maximum desired delays, intraplatoon and interplatoon distances, and platoon size.

UCB-ITS-PWP-94-16 October 1994 24 pp \$7.00

Vehicle Longitudinal Control Test*Sei-Bum Choi*

Evaluates several engine torque control laws for longitudinal vehicle control. The control laws are implemented and tested on a low speed test track. The test results and analysis show that engine manifold air dynamics cannot be neglected, especially at low engine speed.

UCB-ITS-PWP-94-15 October 1994 23 pp \$7.00

Issues in Fault Tolerant Control of Vehicle Follower Systems*J. Karl Hedrick, V. Garg*

Discusses various potential fault modes among sensors and actuators used in cars in vehicle-following experiments, as well as issues of fault detection of sensors and actuators.

UCB-ITS-PRR-94-11 April 1994 32 pp \$7.00

Throttle and Brake Control Systems for Automatic Vehicle Following*P. Ioannou, Z. Xu*

Control systems are designed and tested first using a validated nonlinear vehicle model and then in actual vehicles. Stability is guaranteed by using a constant time headway policy and designing the control system to apply throttle and brake appropriately.

UCB-ITS-PRR-94-10 April 1994 34 pp \$7.00

Adaptive Throttle Control for Speed Tracking*Z. Xu, P. Ioannou*

An adaptive control scheme for an electronic throttle that achieves good tracking of arbitrary constant speed commands in the presence of unknown disturbances. The design, based on a simplified linear vehicle model, is derived from a validated nonlinear one.

UCB-ITS-PRR-94-09 April 1994 17 pp \$5.00

Time Headway Autonomous Intelligent Cruise Controller: Design and Simulations*P.A. Ioannou, F. Ahmed-Zaid, D.H. Wuh*

This scheme maintains a steady state inter-vehicle spacing decided by a desired time headway set by the driver. The longitudinal model of the Lincoln Towncar is used for simulations and testing.

UCB-ITS-PWP-94-07 April 1994 31 pp \$7.00

Modeling of the Brake Line Pressure to Tire Brake Force*T. Xu, P. Ioannou*

Experimental data from a series of tests performed in collaboration with Ford research engineers are used to model the brake line pressure to tire brake force subsystem.

UCB-ITS-PWP-94-06 April 1994 71 pp \$8.00

Vehicle Traction Control and its Applications*Pushkin Kachroo, Masayoshi Tomizuka*

Discusses vehicle traction control and its importance in highway automation. Shows that the system under traction control is stable in the presence of external disturbances, whereas the system under passive control may become unstable in the presence of external disturbances.

UCB-ITS-PRR-94-08 March 1994 41 pp \$7.00

Vehicle Modeling Control AHS*J.K. Hedrick, D.H. McMahon, D. Swaroop*

Simulation results on multiple vehicle platoons demonstrate excellent tracking using spacing-based controllers. The use of headway-based controllers produced degraded performance as compared to the spacing-based controllers.

UCB-ITS-PRR-93-24 November 1993 72 pp \$9.00

Longitudinal Control of the Lead Car of a Platoon*Datta Godbole, John Lygeros*

Schemes that maintain safe spacing, track an optimal velocity and perform various maneuvers (forming, breaking up platoons and changing lanes) are described.

TECH MEMO-93-07 November 1993 31 pp \$7.00

Transitional Platoon Maneuvers in an Automated Highway System*J.K. Hedrick, V.K. Narendran, K.-S. Chang*

An introduction to the control aspect of platoon maneuvers in AHS. The survey is split up into the quasi-synchronous and vehicle follower controller methods of approach.

UCB-ITS-PRR-92-16 December 1992 30 pp \$7.00

Feasibility Study of Advanced Technology HOV Systems. Volume I: Phased Implementation of Longitudinal Control Systems*T. Chira-Chavala, S.M. Yoo*

The study is divided into 5 volumes. Vol. 1 identifies strategies for early deployment of this technology.

UCB-ITS-PRR-92-02 December 1992 111 pp \$11.00

Longitudinal Control of a Platoon of Vehicles with No Communication of Lead Vehicle Information: A System Level Study

Shahab Sheikholeslam, Charles A. Desoer

In case of loss of communication between the lead vehicle and the other vehicles, the performance of the longitudinal control laws degrades; but this degradation is not catastrophic.

TECH MEMO-91-02 August 1991 23 pp \$5.00

Longitudinal Control of a Platoon of Vehicles III: Nonlinear Model

Shahab Sheikholeslam, Charles A. Desoer

A control law is developed and is tested on a simulation of a platoon of 16 vehicles.

UCB-ITS-PRR-90-01 April 1990 24 pp \$5.00

Longitudinal Model Development for Automated Roadway Vehicles

Donn H. McMahon, J. Karl Hedrick

Describes model development for longitudinal analysis and the longitudinal model simulation package, LONSIM. The results of simulations using the power-train model are given.

UCB-ITS-PRR-89-05 October 1989 67 pp \$7.00

Longitudinal Control of a Platoon of Vehicles II: First and Second Order Time Derivatives of Distance Deviations

Shahab Sheikholeslam, Charles A. Desoer

Establishes the benefit resulting from having both first- and second-order time derivatives of distance deviations available.

UCB-ITS-PRR-89-06 August 1989 23 pp \$5.00

Longitudinal Control of a Platoon of Vehicles I: Linear Model

Shahab Sheikholeslam, Charles A. Desoer

A systematic analysis of a longitudinal control law of a platoon of vehicles using a linear model to represent the vehicle dynamics of each vehicle within the platoon.

UCB-ITS-PRR-89-03 August 1989 29 pp \$5.00

Platoon System Behavior

Aerodynamic Performance of Platoons: Final Report

Michael Zabat, Nick Stabile, Stefano Frascaroli, Frederick Browand

The primary purpose of the tests described here is to quantify the behavior of vehicle drag as a function of vehicle spacing. Results show a reduction in average drag for all platoon members as a function of both intervehicle spacing and the number of vehicles in the platoon.

UCB-ITS-PRR-95-35 October 1995 176 pp \$25.00

Low Speed Collision Dynamics and Control: Year One Report

Benson H. Tongue, Ahrie Moon

Discusses issues investigated in the first phase of developing a simulation program to study platoon dynamics in both nominal and emergency scenarios. Preliminary issues include collision detection between the vehicles within the platoon and determining the platoon's post-crash behavior.

UCB-ITS-PRR-95-25 August 1995 22 pp \$5.00

Platoon Collision Dynamics and Emergency Maneuvering IV: Intraplatoon Collision Behavior and A New Control Approach for Platoon Operation During Vehicle Exit/Entry - Final Report

Benson H. Tongue, Yean-Tzong Yang

Examines platoon behavior during non-nominal operations, especially emergency braking.

UCB-ITS-PRR-94-25 November 1994 70 pp \$9.00

Platoon Collision Dynamics and Emergency Maneuvering II: Platoon Simulations for Small Disturbances

Benson H. Tongue, Yean-Tzong Yang

Investigates the effect of selected parameter variations on the response of a platoon, also the response of a platoon under different control algorithms.

UCB-ITS-PRR-94-04 February 1994 53 pp \$7.00

Platoon Collision Dynamics and Emergency Maneuvering III: Platoon Collision Models and Simulations

Benson Tongue, Yean-Tzong Yang

The platoon collision model is used to examine the effect, under four different control algorithms, of non-nominal operating conditions.

UCB-ITS-PRR-94-02 February 1994 53 pp \$7.00

Drag Measurements on a Platoon of Vehicles: A Preliminary Report

Michael Zabat, Stefano Frascaroli, Frederic Browand

Details the design and implementation of wind tunnel tests to evaluate the aerodynamic performance of individual members of 2, 3, and 4-vehicle platoons.

UCB-ITS-PRR-93-27 February 1994 74 pp \$16.00

Platoon Collision Dynamics and Emergency Maneuvering I: Reduced Order Modeling of a Platoon for Dynamical Analysis

B. Tongue, Y.-T. Yang, M. White

Preliminary results have shown that the reduced order model provides an accurate response match with the original model at a substantial computational savings.

UCB-ITS-PRR-91-15 August 1991 59 pp \$7.00

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SYSTEMS

Benefits and Impacts Assessments

Los Angeles Smart Traveler Field Operational Test Evaluation

Genevieve Giuliano, Randolph W. Hall, Jacqueline M. Golob

In response to the Northridge Earthquake of January 1994, an original limited scale FOT based on the I-110 (Harbor Freeway) corridor was switched to target the earthquake affected areas., which greatly broadened the scope of the evaluation.

UCB-ITS-PRR-95-41 December 1995 200 pp \$35.00

TravInfo Field Operational Test Traveler Information Center (TIC) Study (Technology Evaluation Element) Implementation Plan

Mark A. Miller, Randolph Hall

The Traveler Information Center is TravInfo's hub for data collection, processing, and dissemination. Thus the TIC study will focus on TravInfo's overall goal of implementing a system of collecting, integrating, and broadly disseminating timely and accurate traveler information throughout the Bay Area.

UCB-ITS-PWP-95-14 November 1995 29 pp \$10.00

TravInfo Field Operational Test Evaluation Plan

Randolph Hall, Y.B. Yim, Asad Khattak, Mark Miller, Stein Weissenberger

Describes scope, methods, and procedures to measure the effectiveness of the project. The TravInfo evaluation will contain four evaluation elements: institutional, technology, traveler response, and network performance.

UCB-ITS-PWP-95-04 May 1995 64 pp \$15.00

TravInfo Evaluation: Institutional Element Phase 1 Results

Randolph W. Hall, Y.B. Yim, Brian Pfeifle, Stein Weissenberger

The TravInfo project aims to develop a multi-modal traveler information system for the San Francisco Bay Area, developing a partnership between the public and private sectors. This report presents the results of the first wave of institutional interviews, as part of the TravInfo evaluation.

UCB-ITS-PWP-95-01 February 1995 51 pp \$15.00

Transportation Modeling for the Environment

Matthew J. Barth, Joseph M. Norbeck

Describes research dealing with vehicle emissions associated with AHS and ramp metering.

UCB-ITS-PRR-94-27 December 1994 76 pp \$9.00

Modeling IVHS Emission Impacts Volume 1: Background Issues and Modeling Capabilities

Randall Guensler, Simon Washington, Daniel Sperling

Examines general relationships between IVHS technology bundle characteristics and vehicle emission impacts. Primary impacts addressed are those associated with changes in the average speed and operating mode characteristics (acceleration, deceleration, cruise, and idle) of the vehicle.

UCB-ITS-PWP-94-10 October 1994 112 pp \$13.00

Modeling IVHS Emission Impacts Volume 2: Assessment of the CALINE 4 Line Source Dispersion Model

Simon Washington, Randall Guensler, Daniel Sperling

This report assesses the ability of the emission estimating algorithms contained in the CALINE 4 model developed by Caltrans to accurately predict carbon monoxide emissions from a fleet of motor vehicles.

UCB-ITS-PWP-94-11 August 1994 109 pp \$13.00

Investigation of the Costs of Roadway Traffic Congestion: A Preparatory Step for IVHS Benefits Evaluation

Mark A. Miller, Kayin Li

The authors' recommendations for future research developments: 1) a more unified approach to congestion measurement, to improve estimation, 2) techniques for quantifying impacts of congestion that have hitherto been considered qualitatively, and 3) a methodology for quantifying nonrecurring congestion.

UCB-ITS-PRR-94-15 May 1994 51 pp \$7.00

TravInfo Evaluation Plan: Update 1

Youngbin Yim, Asad Khattak, Mark Miller, Randolph Hall, Stein Weissenberger

TravInfo is a Field Operational Test of a centralized database, formed through a public/private partnership, that provides easy access to real-time travel information on all modes of transportation in the San Francisco Bay Area. This report presents an update to the TravInfo evaluation plan, concluding with the system performance evaluation.

UCB-ITS-PWP-94-03 March 1994 66 pp \$7.00

Smart Corridor Evaluation Plan: Conceptual Design

Mark Miller, Asad Khattak, Randolph W. Hall, Genevieve Giuliano, James Moore, Martin Wachs

The specific objectives of this report are to: 1) develop a conceptual structure for the Smart Corridor evaluation, 2) define evaluation data requirements and collection procedures, and 3) select and/or develop data reduction and data analysis methodologies.

UCB-ITS-PRR-94-01 February 1994 61 pp \$7.00

**Highway Electrification and Automation Technologies
—Regional Impacts Analysis Project: Phase III
Appendices: Mobility Statistics**

*Southern California Association of Governments (SCAG) &
Partners for Advanced Transit and Highways (California PATH)*
UCB-ITS-PRR-93-22 November 1993 153 pp \$17.00

**Highway Electrification and Automation Technologies
—Regional Impacts Analysis Project: Phase III:
Impacts Analysis Results**

*Southern California Association of Governments (SCAG) &
Partners for Advanced Transit and Highways (California PATH)*
Focuses on the assessment of regional impacts associated
with application of roadway electrification, and automa-
tion technologies to selected freeway sections in the South-
ern California region.
UCB-ITS-PRR-93-21 November 1993 200 pp \$22.00

**Highway Electrification and Automation Technologies
—Regional Impacts Analysis Project: Phase II:
Scenario for Advanced Highway Technologies**

*Southern California Association of Governments (SCAG) &
Partners for Advanced Transit and Highways (California PATH)*
Focuses on development of a modeling framework for
evaluation of the impacts of several alternative advanced
technologies applied to selected freeway lanes.
UCB-ITS-PRR-93-20 November 1993 249 pp \$27.00

**Highway Electrification and Automation Technologies
—Regional Impacts Analysis Project: Phase I:
Baseline Scenario Data Analysis**

*Southern California Association of Governments (SCAG) &
Partners for Advanced Transit and Highways (California PATH)*
Final report for Phase I. Contains sections on data collected,
baseline forecast for 2025, and electrification and automa-
tion specification scenarios.
UCB-ITS-PRR-93-19 November 1993 121 pp \$15.00

**Highway Electrification and Automation Technologies
—Regional Impacts Analysis Project:
Executive Summary**

*Southern California Association of Governments (SCAG) &
Partners for Advanced Transit and Highways (California PATH)*
How roadway electrification and highway automation could
alleviate the transportation-related problems of freeway
congestion, air pollution, and dependence on fossil fuels in
southern California.
UCB-ITS-PRR-93-18 November 1993 74 pp \$9.00

TravInfo Evaluation Plan

Youngbin Yim, Asad Khattak, Mark Miller, Randolph Hall
The TravInfo project is a field operational test of a central-
ized database in the San Francisco Bay Area.
UCB-ITS-PWP-93-16 November 1993 42 pp \$7.00

Market for IVHS: A Research Perspective

Randolph W. Hall
Brief background information is given on the California
PATH Program, followed by a discussion of benefits evalu-
ation and technology partnerships.
TECH MEMO-93-02 July 1993 11 pp \$5.00

**Systematic Evaluation of the Impacts of Real-Time
Traffic Condition Information on Traffic Flow**

Jeffrey L. Adler, Wilfred W. Recker, Michael G. McNally
Studies drivers' reaction to real-time traffic information.
Involves development of a theoretical model for driver
behavior, interactive simulation experiments, data analysis,
and behavioral modeling.
UCB-ITS-PRR-93-06 June 1993 119 pp \$12.00

**Observations on European Advanced Traveler
Information and Traffic Management Systems**

Youngbin Yim, Jean-Luc Ygnace
The views presented in the report are largely derived from
information gathered at two conferences and from per-
sonal interviews with researchers and government authori-
ties engaged in the European IVHS research effort.
UCB-ITS-PRR-93-23 January 1993 80 pp \$9.00

Potential Payoffs From IVHS: Appendix C

Rockwell International Science Center
This Appendix documents the details of the Intelligent
Vehicle Highway Systems (IVHS) benefit analysis DEMOS
models and provides the PATH user information about
what is contained in and how to use the models.
UCB-ITS-PRR-92-08 August 1992 306 pp \$32.00

Potential Payoffs From IVHS: A Framework for Analysis

Rockwell International Science Center
Relates the various IVHS functions with the public sector
goals they might serve. A new computer tool called DEMOS
was used in these analyses.
UCB-ITS-PRR-92-07 August 1992 133 pp \$15.00

**Potential Contributions of Intelligent Vehicle/
Highway Systems (IVHS) to Reducing
Transportation's
Greenhouse Gas Production**

Steven E. Shladover
IVHS technologies can promote enhanced operational effi-
ciency and reductions in vehicle miles traveled, changes that
could reduce the contribution of the transportation sector
to global warming in ways that are explained qualitatively.
TECH MEMO-91-04 August 1991 18 pp \$5.00

PATH Publications

Communications

Integrated Physical/Link-Access Layer Model of Packet Radio Architectures

Andreas Polydoros

Contributes to a generic conceptual model for system evaluation that can be used for quantification of the interaction between network layers.

UCB-ITS-PRR-95-33 September 1995 126 pp \$20.00

Design and Implementation of Digital Radio Communications Link for Platoon Control Experiments

Wei-Yi (William) Li

Examines the intervehicle communication links implemented in both two- and four-vehicle platoon experiments, and investigates some possible future improvements of the communication link used for platoon control experimentation.

UCB-ITS-PRR-95-02 January 1995 62 pp \$7.00

Infrared Datalink Layer Documentation

Herb Huang, Bret Foreman

Describes the datalink layer (DL) software for an infrared communication link. The software is designed to fit in the structure of an intervehicle communication system.

Tech Note 95-02 January 1995 9 pp \$5.00

ATCOMM/XL Hardware Driver Software Documentation

Herb Huang, Bret Foreman

Complete implementation details for the driver-level software to control the Metacomp ATComm/XL serial communication control board. The software is developed in the C++ language and runs the QNX realtime operating system. This driver is specifically intended for use in an infrared wireless communication system.

Tech Note 95-01 January 1995 11 pp \$5.00

Monitoring the San Francisco Bay Area Freeway Network Using Probe Vehicle and Random Access Radio Channel

Jean-Paul M.B. Linnartz, Marcel Westerman, Rudi Hamerslag

Results presented reveal that random access (ALOHA) transmission of traffic messages is a (spectrum) efficient, inexpensive, and flexible method for collecting road traffic data and that this approach can provide reliable traffic monitoring.

UCB-ITS-PRR-94-23 October 1994 60 pp \$7.00

Integrated Physical/Link-Access Layer Model of Packet Radio Architectures

Andreas Polydoros; contributors Achilleas Anastasopoulos, Te-Kai Liu, Prokopios Panagiotou, Chung-ming Sun

This report contributes to a generic conceptual model for

system evaluation that can be used for quantification of the interaction between network layers.

UCB-ITS-PRR-94-20 October 1994 20 pp \$22.00

Ultrasonic Ranging Control Board Documentation

Jennie Chen, Bret Foreman, Kirill Mostov

Presents an experimental ultrasonic control board designed to run various tests to determine the performance of ultrasonics in a platoon situation. Specifies the theory of operation of version B of the PATH ultrasonic range control board for the IBM PC.

UCB-ITS-PWP-94-09 Revised July 1994 80 pp \$9.00

Communication Requirements and Network Design for IVHS

Ivy Pei-Shan Hsu, Jean Walrand

The communication needs between vehicles and the roadside infrastructure are estimated in terms of message length, frequency, and acceptable delay.

UCB-ITS-PWP-93-18 November 1993 51 pp \$7.00

Spectrum Needs for IVHS

Jean-Paul M.G. Linnartz, Jean Walrand

Summarizes the need for a (dedicated) radio spectrum for IVHS communication services, and concludes that if efficient architectures can be developed, several MHz of spectrum will be needed for large-scale introduction of IVHS services.

UCB-ITS-PWP-93-13 September 1993 29 pp \$7.00

Communication System for the Control of Automated Vehicles

Sonia R. Sachs, Pravin Varaiya

Special emphasis is placed on the more demanding requirements placed by AVCS functions. Presents a communication system architecture that features a 'movable microcell' as an addressable network entity.

TECH MEMO-93-05 September 1993 60 pp \$7.00

Vehicle to Roadside Communications Study

Andreas Polydoros, Khaled Dessouky, Jorge M.N. Pereira, Chung-ming Sun, Kuo-chun Lee, Thomas D. Papavassiliou, Victor O.K. Li

This study emphasizes the architecture and topology aspects of the physical link and access layers connecting moving layers with the fixed infrastructure.

UCB-ITS-PRR-93-04 June 1993 316 pp \$33.00

Dynamic System Modeling

Dynamic Visualization Environment for the Design and Evaluation of Automatic Vehicle Control Systems

Z. Xu

Summarizes the development of software that can animate automated highways, visualize the dynamics of automatic vehicles, and assist in the design and evaluation of automatic vehicle systems.

UCB-ITS-PRR-95-45 December 1995 \$10.00

Object Management Systems

Aleks Ohannes Göllü

Demonstrates the use of the SmartAHS simulation framework by implementing elements of the PATH automation architecture. The resultant OMS application is called SmartPATH.

UCB-ITS-PRR-95-19 June 1995 179 pp \$25.00

Hierarchical Hybrid Control: A Case Study

Datta N. Godbole, John Lygeros, Shankar Sastry

Points out that conventional tools currently in use for the design and verification of control systems may be inadequate for the design of hierarchical control of hybrid systems. The analysis also indicates certain shortcomings of current IVHS design, and proposes solutions to fix these problems.

UCB-ITS-PRR-95-09 April 1995 31 pp \$10.00

DYNAVIS: A Dynamic Visualization Environment for the Design and Evaluation of Automatic Vehicle Control Systems

A. Kanaris, Z. Xu, J. Hauser

DYNAVIS is an interactive engineering environment developed specifically for the design and evaluation of automatic longitudinal and lateral vehicle control systems. DYNAVIS goes far beyond simple animation systems by providing a set of tools to perform interactive visualization with on-line modification of many visualization parameters, such as time and space resolution systems.

Tech Note 94-08 November 1994 11 pp \$5.00

Sy-Control: A Tool for Syntactic Control in Temporal Logic

Akash Deshpande, Pravin Variya

This paper describes Sy-Control, a software tool for syntactic control of discrete event systems (DES). Sy-Control use is illustrated in terms of a simulated application to a critical intersection in Toronto's Queen Street corridor using real data.

Tech Note 94-05 August 1994 14 pp \$5.00

Control of Discrete Event Systems in Temporal Logic

Akash Deshpande, Pravin Variya

This paper presents two approaches to the control of a discrete event system (DES) within the framework of Propo-

sitional Linear Temporal Logic (PLTL). Given the plant behavior and the desired behavior, both described in PLTL, a causal, nonblocking and fair controller is to be synthesized that restricts the system's closed loop behavior to a subset of the desired behavior.

Tech Note 94-04 August 1994 39 pp \$7.00

Interface Between Continuous and Discrete-Event Controllers for Vehicle Automation

John Lygeros, Datta Godbole

The design proposed is a finite state machine that communicates with the discrete controllers by issuing commands that get translated to "jerk" input for the vehicle engine.

UCB-ITS-PRR-94-12 April 1994 25 pp \$5.00

Control of Hybrid Systems

Akash Deshpande, Pravin Variya

To formulate the overall AVCS System, one needs a mathematical framework in which a discrete state system interacts with a set of traditional continuous variable systems. These systems are called hybrid systems. This report, the first in a series documenting work in hybrid systems, develops some theory.

TECH MEMO-93-01 June 1993 33 pp \$7.00

Indirect Adaptive Control of a Class of Interconnected Nonlinear Dynamical Systems

Shahab Sheikholeslam, Charles A. Desoer

Proposes a local indirect adaptive control scheme for the class of interconnected nonlinear dynamical systems suggested by the problem of longitudinal and lateral control of a platoon of vehicles on automated highways.

TECH MEMO-91-01 August 1991 33 pp \$7.00

Electric and Hybrid Vehicles

Broadway Powered Electric Vehicle Project, Track Construction and Testing Program

Systems Control Technology, Inc.

This report covers the construction and testing of an RPEV proof-of-concept system built at the University of California Richmond Field Station. The facility has a 700-foot test track and an operational 35-passenger RPEV.

UCB-ITS-PRR-94-07 March 1994 322 pp \$34.00

Highway Electrification and Automation

Steven E. Shladover

Addresses how the California Department of Transportation and the California PATH Program have made efforts to evaluate the feasibility and applicability of highway electri-

PATH Publications

fication and automation technologies. Experimental results, design study results, and a region-wide application impacts study for Los Angeles.

UCB-ITS-PRR-92-17 December 1992 35 pp \$7.00

PATH Publications

Feasibility Study of Advanced Technology HOV Systems. Volume 2B: Emissions Impact of Roadway-Powered Electric Buses, Light-Duty Vehicles and Automobiles

Mark A. Miller, Victor Dato, Ted Chira-Chavala

Investigates potential near-term air quality benefits due to RPEV's relative to internal-combustion engine vehicles under identical operating conditions.

UCB-ITS-PRR-92-04 December 1992 112 pp \$12.00

Feasibility Study of Advanced Technology HOV Systems. Vol 2A: Feasibility of Implementing Roadway-Powered Electric Vehicle Technology in El Monte Busway: A Case Study

T. Chira-Chavala, Edward H. Lechner, Dan M. Empey

Assesses the feasibility of early deployment of RPEV technology in existing HOV facilities in California.

UCB-ITS-PRR-92-03 December 1992 129 pp \$13.00

Evaluation of Potential Hybrid Electric Vehicle Applications: Volume II: Appendices

Arturo E. Gris

Identifies potentially promising market segments for electric and hybrid vehicle technologies.

UCB-ITS-PRR-91-05 1991 165 pp \$19.00

Evaluation of Potential Hybrid Electric Vehicle Applications: Volume 1

Arturo E. Gris

Covers topics including energy and power requirements, battery and range extender, propulsion system, and air conditioning.

UCB-ITS-PRR-91-04 1991 93 pp \$10.00

Highway Electrification: An Exploration of Energy Supply Implications

Quanlu Wang, Daniel Sperling

The relationship between transportation and electricity demand patterns are investigated for different regions of the country. Implications of electrifying highway transportation for the electricity industry are identified.

UCB-ITS-PWP-87-04 1987 41 pp \$7.00

Heavy Vehicles

Organizing for ITS: Computer Integrated Transportation Phase 2: Results for Commercial Vehicle Operators

Randolph Hall, Indrajit Chatterjee

Extends the research on Computer Integrated Transportation to commercial vehicle operations (CVO), specifically to examine how government can work with trucking companies (i.e., "motor carriers") within a CIT framework.

UCB-ITS-PWP-95-15 November 1995 55 pp \$15.00

Analysis, Design, and Evaluation of AVCS for Heavy-Duty Vehicles: Phase 1 Report

Diana Yanakiev, Ioannis Kanellakopoulos

After a brief description of the dynamic model used in the design and simulations, the authors develop nonlinear controllers with adaptation, first for speed control and then for vehicle follower longitudinal control. Both autonomous operation and intervehicle communication are considered.

UCB-ITS-PWP-95-12 August 1995 39 pp \$10.00

Lateral Control of Commuter Buses

Pushkar Hingwe, Masayoshi Tomizuka

Presents two approaches to the design of lateral controllers for commuter buses based on Sliding Mode Control (SMC).

UCB-ITS-PWP-95-09 July 1995 22 pp \$5.00

Dynamic Modeling of Tractor-Semitrailer Vehicles in Automated Highway Systems

Chieh Chen, Masayoshi Tomizuka

Characterizes the dynamic response parameters, develops control algorithms to achieve automatic guidance, and describes experiments on lateral guidance control of articulated heavy-duty vehicles. Also describes a modeling approach for roll, pitch and yaw motions of tractor-Semitrailer vehicles.

UCB-ITS-PWP-95-08 July 1995 24 pp \$5.00

Engine and Transmission Modeling for Heavy-Duty Vehicles

Diana Yanakiev, Ioannis Kanellakopoulos

In this report, the authors present an overview of engine and transmission modeling for heavy-duty vehicles. The models constructed are suitable for control design and simulation, and they are used in the Advanced Vehicle Control Systems (AVCS) design for trucks and buses.

Tech Note 95-06 August 1995 63 pp \$15.00

Communications and Positioning Systems in the Motor Carrier Industry

Dimitris A. Scapinakis, William L. Garrison

New technologies for determining the positions of trucks and for communications to and from trucks are reviewed.

The potential for integration of information from the trucking industry has not yet been considered by the IVHS community.

UCB-ITS-PRR-91-10 1991 81 pp \$10.00

Studies of the Adoption and Use of Location and Communication Technologies by the Trucking Industry

Dimitris A. Scapanikis, William L. Garrison

Describes eight tasks to be undertaken in an investigation of communication technologies in the trucking industry.

UCB-ITS-PRR-91-02 1991 20 pp \$5.00

Freight Transportation and Highway Automation: Research on Advanced Technologies for Goods Movement as an Integral Part of the PATH Program

Ann D. Stevens

Good design builds flexibility into itself. PATH participants can enhance their design capabilities by studying the paths taken so far by passenger and freight systems and recognizing similar patterns.

UCB-ITS-PWP-87-02 December 1987 21 pp \$5.00

Transportation Modeling

Simple Physical Principle for the Simulation of Freeways with Special Lanes and Priority Vehicles

Carlos Daganzo, Wei-hua Lin, Jose M. del Castillo

Presents a remarkably simple physical principle that can be used to solve the kinematic wave problem for freeways with special lanes and priority vehicles.

Tech Note 95-09 December 1995 39 pp \$10.00

Continuum Theory of Traffic Dynamics for Freeways with Special Lanes

Carlos F. Daganzo

The proposed simple model is attractive because its mathematical formulation requires very few data that are easy to obtain, and also because its solution can be described completely by a set of diagrams that are intuitive.

Tech Note 95-08 December 1995 46 pp \$10.00

Turning Movement Estimation in Real Time (TMERT)

Peter T. Martin

Describes a new transportation planning model that can monitor system performance and derive management and control strategies in real time. It offers a method of estimating turning movement flows from link detected flows at small recurrent intervals in real time. The model is shown to be transferable through estimation of turning movements from a real Californian City.

UCB-ITS-PRR-95-29 September 1995 178 pp \$25.00

PLANiTS: The Case-based Reasoner as a Planning Tool for Intelligent Transportation Systems

Asad Khattak, Adib Kanafani

Develops a data synthesis methodology in PLANiTS using case-based reasoning. Also discuss issues related to computer implementation and the limitations of case-based reasoning.

UCB-ITS-PRR-95-23 July 1995 26 pp \$10.00

ComBehQ: A Combined Behavioral and Queuing Model User's Guide

Asad Khattak, Haitham Al-Deek, Paramsothy Thananjeyan

The model offers a framework for assessing the impacts of auto-related ATIS technologies during incident related congestion.

Tech Note 95-05 July 1995 42 pp \$10.00

PLANiTS: Organization and Integration of Modules

Thananjeyan Paramsothy, Asad Khattak, David Lovell, Adib Kanafani

Discusses the integration of PLANiTS components, which is achieved by defining a structure for representing transportation improvement actions, performance measures and environment in terms of spatial, temporal and user dimensions.

UCB-ITS-PRR-95-18 June 1995 45 pp \$10.00

PLANiTS: The Methods Base, Model Selection and Model Integration

Rosella Picado, Asad Khattak, David J. Lovell, Adib Kanafani

Functions of the Methods Base discussed include representation of model chains, selection of models and data, and data transformations and aggregation. The Methods Base features are illustrated with an example drawn from the PLANiTS prototype (version 1.0).

UCB-ITS-PRR-95-16 May 1995 60 pp \$15.00

PLANiTS: A User's Guide for the Prototype

Randall Cayford, Asad Khattak, Adib Kanafani

The prototype has a planning vector that allows users to enter and edit transportation actions, performance measures and environmental descriptors. This guide demonstrates how users specify each of these elements in terms of temporal, spatial, and user dimensions and analyze the planning vector with models and case-based reasoning.

UCB-ITS-PRR-95-13 May 1995 25 pp \$5.00

Ideal Dynamic User-Optimal Route Choice: A Link-based Variational Inequality Formulation

Bin Ran, David E. Boyce

Presents traffic network constraints and link-based DUO route choice conditions, and introduces a link-based variational inequality (VI) formulation that avoids route enumeration in both the formulation and the solution procedure.

UCB-ITS-PWP-95-07 May 1995 27 pp \$10.00

PATH Publications

Link-Based Variational Inequality Model for Dynamic Departure Time/Route Choice*Bin Ran, Randolph W. Hall, David E. Boyce*

The dynamic user-optimal (DUO) departure time and route choice problem is to determine travelers' best departure times and route choices at each instant of time. The authors present a formulation for the problem that avoids route enumeration in both formulation and solution procedure.

UCB-ITS-PWP-95-06 May 1995 34 pp \$10.00

PLANiTS: A Functional Description*Asad Khattak, Adib Kanafani*

Describes Planning and Analysis Integration for Intelligent Transportation Systems, a process-based computer system that translates transportation project problems and goals to performance measures, examines possible competing and complementary actions that can address the problems, systematically evaluates the impacts of actions by using appropriate knowledge-based and model-based tools, and supports human communication and interaction between planning group members.

UCB-ITS-PRR-95-07 March 1995 41 pp \$10.00

Validating the Basic Cell Transmission Model On a Single Freeway Link*Wei-Hua Lin, Dike Ahanotu*

The cell transmission model, developed as a discrete version of the hydrodynamic theory of traffic flow, is capable of automatically tracking shocks and acceleration waves and thus capturing traffic behavior in the process of the formation, propagation, and dissipation of queues. This note examines the performance of the basic model for both congested and uncongested traffic based on the field data from a segment of I-880 in California.

Tech Note 95-03 March 1995 89 pp \$15.00

SmartPath Version 2: An Automated Highway System Simulator*Farokh Eskafi, Delnaz Khorramabadi, Pravin Varaiya*

A guide to version 2 of SmartPath.

Tech Note 94-03 December 1994 28 pp \$5.00

Technical Description of NETCELL: General Framework and Data Structure*Wei-Hua Lin, Carlos F. Daganzo*

Discusses implementation of a prototype of a freeway network simulation program, NETCELL, in detail, including cell representation for a freeway network with three-legged junctions, data and file structures, inputs and outputs, and some key algorithms developed to model traffic progression in junctions.

Tech Note 94-07 October 1994 35 pp \$7.00

Simulation Modeling of the Santa Monica Freeway*Loren D. Bloomberg, Adolf D. May*

Describes the strategies, limitations, and assumptions needed to code the Santa Monica Freeway using the FREQ and INTEGRATION simulation tools. The report ends with indilations and suggestions for future research.

UCB-ITS-PWP-94-14 September 1994 103 pp \$13.00

Cell Transmission Model: Network Traffic*Carlos F. Daganzo*

Shows how the evolution of multicommodity traffic flows over complex networks can be predicted over time, based on a simple macroscopic computer representation of traffic flow that is consistent with the kinematic wave theory under all traffic conditions.

UCB-ITS-PWP-94-12 August 1994 18 pp \$5.00

SmartPath User's Manual*Farokh Eskafi, Delnaz Khorramabadi*

Instruction on how to compile, run, and use all modules of SmartPath in both the batch or interactive modes.

Tech Note 94-02 June 1994 24 pp \$5.00

Simulation-Based Framework for the Analysis of Traffic Networks Operation with Real-Time Information*R. Jayakrishnan, Michael Cohen, John Kim, Hani S. Mahmassani, Ta-Yin Hu*

Discusses the simulation approach of DYNASMART. Results from the simulation of traffic management for special-events traffic from the Anaheim stadium are presented.

UCB-ITS-PRR-93-25 November 1993 96 pp \$11.00

Decision Support and Consensus Building for PLANiTS*Adib Kanafani, Melanie Crotty*

PATH researchers have developed a framework to integrate planning and analysis in a computer-supported environment that facilitates deliberation and consensus seeking. This framework is called Planning and Analysis to Integrate Intelligent Urban Transportation Systems or PLANiTS.

UCB-ITS-PWP-93-20 November 1993 49 pp \$7.00

SmartPath Simulator - Version MOU62*Bruce Hongola, Jacob Tsao, Randolph Hall*

User instructions and software design description for version MOU62 of the SmartPath Simulator.

UCB-ITS-PWP-93-08 August 1993 56 pp \$7.00

Simulation of IVHS on the Santa Monica Freeway Corridor Using the INTEGRATION Model. Phase 2: Preliminary ATIS and ATMS Experiments

Yonnel Gardes, Adolf D. May

Strategies to be tested include freeway ramp metering, real-time traffic signal optimization, route-guidance systems, and combinations of these strategies. Investigations are performed for the morning peak period under both incident-free and incident traffic conditions.

UCB-ITS-PWP-93-06 August 1993 43 pp \$7.00

Properties of Link Travel Time Functions Under Dynamic Loads

Carlos F. Daganzo

Shows that such functions only make some physical sense in the special case where each function denotes either a link with no spatial dimension containing a point queue, or a link with constant travel time and no queuing.

UCB-ITS-PWP-93-05 August 1993 10 pp \$5.00

Rapid Prototyping of Advanced Driver Interface Systems

Lauren J. Massa, Max B. Mendel

This report describes a computer environment for rapidly prototyping user interfaces for advanced driver information systems (ADIS).

UCB-ITS-PRR-93-08 August 1993 20 pp \$5.00

Cell Transmission Model. Part I: A Simple Dynamic Representation of Highway Traffic

Carlos F. Daganzo

This representation can be used to predict traffic's evolution over time and space, including transient phenomena such as the building, propagation and dissipation of queues. The representation's simplicity should make it possible to keep track of each vehicle's final destination throughout a simulation, even for complex networks.

UCB-ITS-PRR-93-07 July 1993 60 pp \$7.00

Spatial Evolution of Queues During the Morning Commute in a Single Corridor

Carlos F. Daganzo, Wei-Hua Lin

Presents a qualitative description of the evolution of traffic congestion. We found that unreasonable results are obtained with "point queue" models, currently a favored approach in the dynamic traffic assignment literature.

UCB-ITS-PWP-93-07 July 1993 23 pp \$5.00

Spatial Evolution of Traffic Under the Two-Wave Speed Assumption: A Shortcut Procedure and Some Observations

Carlos F. Daganzo

This paper describes the behavior of traffic in a homogeneous highway according to the hydrodynamic theory in

the special case where the flow-density relationship is triangular; i.e., when only two wave velocities exist.

UCB-ITS-PWP-93-03 July 1993 25 pp \$5.00

Planning Methodology for Intelligent Urban Transportation Systems

Adib Kanafani, Asad Khattak, Melanie Crotty, Joy Dahlgren

This study presents a framework for integrating planning and analysis in a computer supported environment that facilitates deliberation and consensus seeking.

UCB-ITS-PRR-93-14 June 1993 120 pp \$14.00

Simulation of IVHS on the Smart Corridor Using the INTEGRATION Model

Yonnel Gardes, Adolf D. May

Describes Phase I of the project, in which the INTEGRATION traffic simulation model is used to help simulate ATIS and ATMS on a freeway/arterial environment.

UCB-ITS-PRR-93-03 May 1993 90 pp \$10.00

SmartPath: An Automated Highway System Simulator

Farokh Eskafi, Delnaz Khorramabadi, Pravin Varaiya

SmartPath is a simulator for an AHS. This document explains how the simulation is organized: an example illustrates the use of SmartPath.

TECH MEMO-92-03 October 1992 51 pp \$5.00

Evaluation of Highway Bottlenecks

Randolph Hall, M. Kamoun

Final report of the PATH research project "Bottleneck Evaluation Model." Key issues include the effects on (1) incident frequency, duration and reliability; and (2) changes in traveler behavior, in the forms of arrival time choice and renegeing.

UCB-ITS-PRR-91-09 July 1991 42 pp \$7.00

BTS (Version 1.1) - Bottleneck Traffic Simulator User's Manual

Wei H. Lin, Randolph W. Hall

This new version of BTS was enhanced to include incident dependencies, variable weather conditions, renegeing, and randomly varying traffic volumes.

UCB-ITS-PWP-91-06 July 1991 31 pp \$5.00

Model Selection and Initial Application of CONTRAM Model for Evaluation In-Vehicle Information Systems

Yonnel Gardes, Bruce Haldors, Adolf D. May

An initial evaluation of in-vehicle information systems and the applicability of the model is made.

UCB-ITS-PRR-91-11 June 1991 166 pp \$18.00

PATH Publications

BTS (Version 1.0) - Bottleneck Traffic Simulator User's Manual*Wei Hua Lin, Randolph W. Hall*

Describes the computer program BTS, a macroscopic tool for simulating the performance of freeway bottlenecks.

UCB-ITS-PWP-91-01 March 1991 27 pp \$5.00

Traffic Modeling to Evaluate Potential Benefits of Advanced Traffic Management and In-Vehicle Information Systems in a Freeway/Arterial Corridor*Yonnel Gardes, Adolf D. May*

Includes a literature review of existing traffic simulation models.

UCB-ITS-PRR-90-03 1990 69 pp \$9.00

Development of a Dynamic Equilibrium Assignment Procedure for Network-Level Analysis of New Technology*Edward C. Sullivan, Sun Wong*

Identifies a network traffic assignment procedure to be used in the analysis and evaluation of new technologies deployed in selected corridors containing High Occupancy Vehicle (HOV) facilities.

UCB-ITS-PRR-89-04 August 1989 92 pp \$11.00

Transportation Policy and Planning Issues**Socioeconomic Attributes and Impacts of Travel Reliability: A Stated Preference Approach***Kenneth A. Small, Robert B. Noland, Pia Koskenoja*

Examines behavioral reactions to the impact of changes in the probability of a non-recurrent incident and how this effects the expected costs of a commute trip. Assesses the impact of socioeconomic variables, with a detailed classification of occupational groupings.

UCB-ITS-PRR-95-36 November 1995 115 pp \$20.00

Institutional Challenges to the Development and Deployment of ITS/ATS Systems in California*Thomas A. Horan, Lamont C. Hempel, Margo Bowers*

Findings are based on a series of in-depth interviews and review of research related to "non-technical" constraints both in California and at the national level. The study outlines three core areas that require attention: research collaboration, regional management, and stakeholder acceptance.

UCB-ITS-PRR-95-17 May 1995 114 pp \$20.00

Role of Teamwork in a Planning Methodology for Intelligent Transportation Systems: Volume 1*Adib Kanafani, M. Manheim, A. Khattak, N. Vlahos*

The methodology proposed exploits emerging information technologies to develop decision support for the teamwork found in transportation planning problems. The

concept of a Building Block Function is introduced as the functional form of the decision support that the computer system PLANITS should provide.

UCB-ITS-PWP-94-08 May 1994 33 pp \$7.00

Studies of Road Infrastructure Requirements for Small Innovative Vehicles*William L. Garrison*

Road infrastructure modifications for a 500 to 700 pound, 1 + occupant commuter car include restriping, provision of special lanes, and flyovers. These modifications could sharply increase capacity and could be achieved incrementally at low cost.

UCB-ITS-PRR-93-16 November 1993 93 pp \$11.00

Summary of Observations on July 1993 Study Tour to Japan*Donald E. Orne, Steven E. Shladover*

The authors report on visits with academic institutions, government ministries, and automotive companies. Also an overview of the Intelligent Vehicle '93 Conference.

UCB-ITS-PWP-93-14 October 1993 23 pp \$5.00

Small Cars in Neighborhoods*Peter C. Bosselmann, Daniel Cullinane, William Garrison, Carl M. Maxey*

Reviews the development of small vehicles and roads suited to their use and considers community development trends that might encourage or thwart the adoption and use of such vehicles.

UCB-ITS-PRR-93-02 April 1993 87 pp \$10.00

Restructuring the Automobile/Highway System for Lean Vehicles: The Scaled Precedence Activity Network (SPAN) Approach*Mark E. Pitstick, William L. Garrison*

Investigates the introduction of parking and road facilities for lean vehicles: small, one- or two-passenger vehicles that consume less energy and produce less pollution and congestion than present vehicles.

UCB-ITS-PRR-91-07 April 1991 189 pp \$20.00

Second Annual Symposium on Advanced Traffic Management Systems (ATMS) and Advanced Traveler Information Systems (ATIS)*Adolf May, Bruce Haldors*

Summary of the presentations made at the symposium.

UCB-ITS-PRR-91-01 November 1990 29 pp \$5.00

Lean Machines: Preliminary Investigations

William L. Garrison, Mark E. Pitstick

Information from early work on the potential for the General Motors small and energy efficient Lean Machine vehicle in California markets.

UCB-ITS-PRR-90-04 July 1990 46 pp \$7.00

Opportunities and Constraints for Advanced Highway Technologies: A Speculative Analysis.

Executive Summary

Elizabeth A. Deakin

Discusses technology options, application opportunities, and barriers to the introduction of advanced highway technologies. An executive summary to PATH Research Report 89-7.

UCB-ITS-PRR-89-08 October 1989 17 pp \$5.00

Opportunities and Constraints for Advanced Highway Technologies: A Speculative Analysis

Elizabeth A. Deakin

Considers the possibilities raised by proposed highway technologies and applications, as a basis for the exploration of questions about the technologies' effects.

UCB-ITS-PRR-89-07 October 1989 48 pp \$7.00

Using Technology to Improve Transportation Services

William L. Garrison

The search for improvements is focused on marginal changes in service quality of decreases in costs. Electronics technology, for example, is being applied to smooth highway traffic, improve microwave aircraft landing systems, and tighten shippers' logistics systems.

UCB-ITS-PWP-88-07 May 1988 32 pp \$7.00

Transportation Opportunities and Constraints: The Performance of Urban Highway Transportation

William L. Garrison

Considers system performance as such and the status of the economic and social services enabled by the system.

UCB-ITS-PWP-87-05 December 1987 24 pp \$5.00

Status of Foreign Advanced Highway Technology

Adib Kanafani, Howard R. Ross, Robert E. Parsons

Analyzes conditions in Europe and Japan.

UCB-ITS-PRR-87-02 October 1987 49 pp \$7.00

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Based upon the vast holdings of the Library of the University of California's Institute of Transportation Studies, the PATH Database includes abstracts covering books, journal articles, conference papers, technical reports, dissertations and selected news articles. Papers from transportation and engineering society proceedings, journals and reports comprise the core of the Database. These include contributions from the Transportation Research Board, ITS America, the California PATH Program, the Institution of Electrical Engineers, IEEE, ISATA, SPIE and scores of other scholarly organizations. Documents received on worldwide information exchange agreements from international programs such as DRIVE, PROMETHEUS, and ERTICO, also form another core group of records.

The PATH Database is constructed using Inmagic software and can be remotely searched by users associated with the California PATH Program. A printed monthly current awareness service, "Recent Additions to the PATH Database", informs ITS professionals of current information. This publication is also accessible on the World Wide Web at: <http://www.lib.berkeley.edu/~path/index.html>. The entire PATH Database will soon be available for searching on the Internet.



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Steve Morris at: smorris@library.berkeley.edu

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Institute of Transportation Studies
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Berkeley, CA 94720

NO: 8049

AU Adams, Lisa D.; Flannagan, Michael J.; Sivak, Michael
 CORP University of Michigan, Transportation Research Institute
 TI Obstacle avoidance maneuvers in an automobile simulator.
 DT 1995.
 PUB University of Michigan, Transportation Research Institute, Ann Arbor MI
 REP RCE-939402; UMTRI-95-3
 PG iii, 20 p..
KW Automobile driving; Driving simulators; Human factors.

AB This study was conducted to determine the strategies subjects use to avoid an obstacle on the road with a limited preview distance at a relatively high speed, and to investigate whether these strategies are influenced by driver age and sex. The studies were conducted in a driving simulator.

REFNO: 8051

AU Kihl, Mary
 TI Improving interbus transfer with automatic vehicle location.
 DT 1995
 CORP Midwest Transportation Center, Ames, Iowa
 SP Iowa Dept. of Transportation; United States Dept. of Transportation
 PG 57 p..
KW Automatic vehicle location; Public transit; Paratransit services; Global positioning system.

AB This report presents an overview of automatic vehicle location (AVL) technology and its applications to public transit. It gives an assessment of the application to the Des Moines Metropolitan Transit Authority. A review of issues associated with application to a rural demand-responsive system is discussed. Finally, an assessment of components for an AVL application and a set of recommendations are presented.

REFNO: 8077

AU Hsu, Pau-Lo, Lin, Ken-Li, Shen, Li-Cheng
 CORP Kuo li chiao tung ta hsueh. Institute of Control Engineering
 ART Diagnosis of multiple sensor and actuator failures in automotive
 SO IEEE transactions on vehicular technology. Vol. 44, no. 4
 DT November 1995.
 PG p. 779-789
KW In vehicle sensing systems; Fault monitoring

AB This paper presents a diagnostic system which can effectively identify multiple sensor and actuator failures in engines systems. Simulation and experimental results indicate the the proposed system not only can be applied to cases where all failures occur in the same sector, but is also appropriate for isolating multiple failures occurring simultaneously in sensors and actuators

REFNO: 8079

AU Lacey, Neil; Cameron, Max
 ART Mayday in the Rockies : Colorado's GPS-based emergency vehicle location system.
 SO GPS world. Vol. 6, no. 10
 DT October 1995
 PG p. 40-47
KW Automatic vehicle location; Global Positioning System; Motorist aid systems

AB This article describes an GPS (Global Positioning System)-based emergency vehicle location system being developed through a public partnership in Colorado. The program, which is among the first of its kind in the U.S., has just passed its first milestone - prototype demonstration of the emergency vehicle location technology - and is proceeding toward full-scale testing and deployment in a test area in and around Denver.

REFNO: 8083

AU Hollis, B.J.
 ART Telematics and information for the automobile user : the intelligent car
 SO Smart vehicles
 DT 1995
 PUB Swets & Zeitlinger, Lisse, Netherlands
 PG p. [37]-44.
KW Driver information systems; Telematics; ERTICO (Organization)

AB This paper begins with a general discussion on the benefits of telematics. It then describes ERTICO, the European Road Transport Telematics Implementation Coordination Organization. It gives a brief description of the different sectors identified by ERTICO which form the system of road transport telematics. These include: traffic management, pre-trip management, on-trip management, vehicle control, freight and fleet management, and automatic fee collection.

REFNO: 8109

AU Sexton, G.
 CORP University of Northumbria at Newcastle
 ART Advances in automated pedestrian counting
 SO European Convention on Security and Detection (1995 : Brighton, England)
 DT 1995
 PUB Institute of Electrical Engineers, London
 PG p. 106-110
KW Image processing; Pedestrian detectors; Real time information

AB This report focuses on the PEDMON (PEDestrian MONitoring) project which studies the development of technologies for automated pedestrian counting. The report describes the video image processing work, hardware and network development associated with the project. In the first section, aspects of the image processing algorithms are discussed. In the second section, the hardware and network developed for the intelligent sensors are detailed. In the third section, the system performance is discussed based on real data taken from the installation at the St. Lazare Railway Station in Paris.


 PATH Database
REFNO: 8111

AU Grabow, P.C.; Liu, L.
 CORP Daylor University, Dep. of Computer Science
 ART Automatic generation of C++ code from an ESCRO2 specification
 SO International Computer Software and Applications Conference (19th : 1995 : Dallas, Tex.). Proceedings. COMPSAC '95
 DT 1995
 PUB IEEE Computer Society Press, Los Alamitos CA
 PG p. 18-24
KW Real time control; Traffic signals; Traffic control

AB ESCRO2 is a specification language for real time systems. This paper describes the capabilities of the ESCRO2 processor to generate C++ code from an ESCRO2 specification. A traffic light control system is used to illustrate the concepts.

REFNO: 8113

AU Arnold, James A.
 CORP United States, Federal Highway Administration
 ART Navigating the future
 SO Public roads. Vol. 59, no. 2
 DT Autumn 1995
 PG p. 4-10
KW Global Positioning System; Intelligent transportation systems

AB This article explains how electronic and other high-tech "gadgets" are being used to enhance efficient transportation and emphasizes how the transportation uses of technologies originally developed for national defense. The article focuses on GPS (Global Positioning System) and SPS (Standard Positioning System) and covers the areas of errors, user needs and requirements, augmented SPS (Standard Positioning Service), and possible future developments.

REFNO: 8130

AU Chatziioanou, Alypiou
 CORP California Polytechnic State University, San Luis Obispo
 ART Video image processing systems : applications in transportation
 SO Vehicle Navigation and Information Systems Conference (6th : 1995 : Seattle, Wash.). 1995 Vehicle Navigation & Information Systems Conference proceedings
 DT 1995
 PUB IEEE Service Center, Piscataway NJ
 PG p. 17-20
KW Traffic surveillance; Image processing

AB This paper reports on a two phased study which assessed the potential of using video image processing (VIP) systems for traffic surveillance and detection on California freeways. Under phase one, eight turn-key and prototype systems were identified and tested under laboratory conditions. In phase two, four VIP systems were chosen for extended field testing to measure various factors. This paper presents the Phase II field test results and recommendations for standardizing image processing systems with a view toward eventual statewide implementation for traffic detection.

REFNO: 8133

AU Chang, Amoeba T.S.
 CORP Tan-chiang ta hsueh
 ART Adaptive signal control expert by artificial neural network training
 SO Vehicle Navigation and Information Systems Conference (6th : 1995 : Seattle, Wash.).
 1995 Vehicle Navigation & Information Systems Conference proceedings
 DT 1995
 PUB IEEE Service Center, Piscataway NJ,
 PG p. 35-39
KW Advanced traffic management systems; Adaptive control systems; Neural networks; Traffic signals.

AB This paper describes an advanced signal system (INTELS) with the subsystem Intelligent Traffic Signal control Software (ITSS). Focus is on determining signal phases and timing. Expert systems and an artificial neural network model are used in dealing with the range of control requirements.

REFNO: 8147

AU Schrijver, Peter Ronald
 CORP Technische Universiteit Delft
 TI Supporting fleet management by mobile communications
 DT 1993
 PUB National Technical Information Service, Springfield VA
 PG 240 p
KW Trucking; Commercial vehicle operations; Mobile communication

AB This dissertation investigates the possibilities mobile communications have to support the daily tasks of road haulage dispatchers. It focuses on the development of an information system that incorporates mobile communication technology and on establishing the benefits of using such an information system.

REFNO: 8150

AU Campbell, Darwin; Bradshaw, Catherine
 TI Riderlink : transportation options on the Internet
 DT 1995
 PUB American Public Transit Association, Washington DC
 PG 10, [2] p
KW Public transit; Advanced traveler information systems; Computer networks

AB This paper describes Riderlink, a World Wide Web site on the Internet which provides electronic information about transportation options in the Seattle/Puget Sound Region. The focus of the project is to provide, via home and office PCs and kiosks, a broad range of transportation options information.

REFNO: 8155

AU Sandler, Larry
 ART Big bus driver is watching : new system tracks routes, riders
 SO Milwaukee Journal Sentinel
 DT July 19, 1995
 PG p. B7.
KW Automatic vehicle location; Buses; Satellite telecommunication.

AB This article describes the Milwaukee County Transit System's use of satellites to track the location of buses in their fleet. This \$7.9 million Smart-Track communications and vehicle locator also indicates to transit system dispatchers which bus is on schedule, has taken a wrong turn or needs help from security officers or maintenance workers

REFNO: 8158

AU Catchpole, John; Hancock, Adrian; Cairney, Peter
 CORP ARRB Transport Research Ltd.
 TI Driver comprehension of formats for presenting traffic information on dynamic signs
 DT 1995
 SER Research report ARR; 269
 PUB ARRB Transport Research Ltd., Vermont South, Vic.
 PG 106 p
KW Variable message signs; Traffic signs; Driver information systems

AB This report describes the Drive Time system which was begun in July 1995 on Melbourne's South Eastern Arterial to provide drivers with information about traffic conditions and incidents on the arterial. Before installation of the Drive Time system, driver comprehension of various possible formats for the Trip Information Signs was investigated. Formats investigated included

vehicle speeds, travel times and descriptive labels. Color coding of the signs was also studied to see if it would result in improved comprehension of the information presented.

REFNO: 8171

AU Hickman, Mark D.; Wilson, Nigel H.M.
ART Passenger travel time and path choice implications of real-time transit information
SO Transportation research. Part C, Emerging technologies. Vol. 3C, no. 4 (Aug. 1995)
SP University Transportation Centers Program (U.S.); Massachusetts Bay Transportation Authority
PG p. 211-226
KW Travel behavior; Travel time; Advanced traveler information systems; Public transit

AB This paper considers information systems in public transit in which the passenger receives information in real time regarding projected vehicle travel times. To provide a preliminary assessment of these systems, an analytic framework is presented to evaluate path choices and travel time benefits resulting from real-time information. A behavioral model of transit path choice is presented that frames the choice in terms of a decision whether to board a departing vehicle. This path choice model accommodates network travel times that are both stochastic and time-dependent. The path choice model is extended to demonstrate how real-time information may be incorporated by the passenger in making a path choice decision. This analytic framework is applied to a case study corridor at the Massachusetts Bay Transportation Authority, using a computer simulation to model vehicle movements and passenger path choices in the corridor.

NO 8520

AU Kiselewich, Stephen J.; Turner, Douglas D.
CORP Delco Electronics Corporation
ART Using a neural network to distinguish between deployment events and non-deployment events in a supplemental inflatable restraint system
SO Automotive electronics; a review of technical achievements at Delco Electronics
DT 1995
PG p. 5-10
KW neural networks; traffic accidents; vehicle technology

AB This article describes an advanced supplemental inflatable restraint (SIR) controller which uses a three-layer, fully interconnected, feedforward neural network to distinguish between deployment and nondeployment events.

NO 8530

AU Taylor, Steven T.
ART Losing Wait
SO ITS World, Vol. 1, no. 1
DT January/February 1996
PG p. 28-31
KW weigh in motion; automatic vehicle identification; commercial vehicle operations; trucking; Advantage I-75 (Program)

AB This article reviews the Advantage I-75 Program and describes how weight-in-motion, automatic vehicle identification (AVI) readers, and in-vehicle transponders are helping truckers speed past weigh stations without compromising safety.

NO 8568

AU Goolsby, Merrell E.; McCasland, William R.
CORP Texas Transportation Institute
TI Houston ITS priority corridor program plan
DT 1995
SER TTI research report; 2931-2
PUB Texas Transportation Institute, College Station, TX
SP Texas Dept. of Transportation, Office of Research and Technology Transfer
REP FHWA/TX-95/2931-2
PG 98 pg in various pagings
KW Intelligent transportation systems; advanced traffic management systems; advanced traveler information systems

AB This report documents development of the 20-year Houston Intelligent Transportation Systems (ITS) Priority Corridor Plan. It is structured in three implementation time frames; Short Range, Intermediate Range, and Long range. There are 37 individual deployment projects identified in the Plan. The Plan builds upon the existing and evolving ITS core infrastructure of the Corridor, ranging from technologies such as the freeway and HOV lane Computerized Transportation Management System, Electronic toll Collection System, Automatic Vehicle Identification, computerized traffic signals, motorist assistance program, METRO smart bus, and the Houston TranStar center.

NO 8598

AU Cutting, April; Porter, Ron; Mannering, Fred L.

CORP Washington State Transportation Center

TI Development and evaluation of an incident response database for Washington State

DT 1995

PUB Washington State Dept. of Transportation, Olympia WA

SP Washington (State) Dept. of Transportation

REP WA-RD 352.1

PG 210 p. in various pagings

KW Incident Management; Advanced Traffic Management Systems; Geographic information systems

AB This study reports on the development and evaluation of an incident response database for the State of Washington. The database program takes into account the difficulty of quantifying the effectiveness of incident management procedures due to the lack of appropriate data. Interviews with incident management personnel were conducted to help develop the database program.

NO 8658

AU Okunieff, Paula

ART Location referencing methods for Intelligent Transportation Systems (ITS) User Services; recommended approach

SO Geographic Information Systems for Transportation (GIS-T) Symposium (8th: 1995; Sparks, Nev.). Proceedings of the 1995 Geographic Information Systems for Transportation (GIS-T) Symposium

DT 1995

PUB American Association of State Highway and Transportation Officials, Washington DC

PG p. 57-75

KW Geographic Information Systems; digital mapping; intelligent transportation systems

AB This paper focuses on analyzing location referencing methods most appropriate for Intelligent Transportation Systems (ITS) User Services. The paper begins with a discussion of five location referencing methods and effective strategies for implementing them. The components which are common to the five methods are examined and show how they form, in part, the basis of a set of standards for a Location Referencing System for ITS user services. This system permits multiple location referencing methods and coding schemes to operate within a single framework.

NO 8683

CORP Intelligent Vehicles '95 Symposium (1995: Detroit, Mich.)

TI Proceedings of the Intelligent Vehicles '95 Symposium, September 25-26, 1995, Detroit, USA

DT 1995

PUB IEEE Service Center, Piscataway NJ

SP IEEE Industrial Electronics Society

PG x, 537 p.

KW Advanced Vehicle Control Systems; Robotics; Computer Vision; Image Processing

AB This proceedings consists of 90 papers presented at the Intelligent Vehicles '95 Symposium held in Detroit, Mich., Sept 25-26, 1995, and sponsored by the IEEE Industrial Electronics Society. The proceedings covers a wide variety of topics related to advanced vehicle control for both motor vehicles and industrial robots.

NO 8741

AU Hedrick, J.K.

CORP University of California, Berkeley. Institute of Transportation Studies; University of California, Berkeley. Dept. of Mechanical Engineering; Partners for Advanced Transit and Highways (Calif.)

TI Longitudinal control development for IVHS fully automated and semi-automated systems, Phase II.

DT 1996

SER PATH Research Report; UCB-ITS-PRR-96-1

PUB California PATH Program, Institute of Transportation Studies, University of California, Berkeley, Berkeley, CA

SP California Dept. of Transportation

REP UCB-ITS-PRR-96-1

PG 126

KW Advanced vehicle control systems; automatic braking; intelligent transportation systems; longitudinal guidance; traffic platooning

AB This report studies performance issues in Automated Vehicle Control Systems (AVCS). Specifically, it addresses the automatic braking controller design issues, effects of braking on

Intelligent Vehicle Highway Systems (IVHS) lane capacity, performance of platoons with various information structures, and fault detection filter design for AVCS.

NO 8829

AU Asawa, Manjari; Stark, Wayne E.
CORP University of Michigan. Dept. of Electrical Engineering and Computer Science
ART Cellular digital packet data for intelligent vehicle highway systems
SO IVHS journal. Vol 2, No. 4
DT November 1995
PG p. 341-358
KW Cellular radio; driver information systems; data transmission systems

AB This paper studies data communication aspects of cellular networks. Focus is on Cellular Digital Packet Data (CDPD). The relevant features of CDPD are summarized and the capacity of a CDPD is computed. The suitability of CDPD for Intelligent Vehicle Highway Systems (IVHS) is explored.

NO 8843

AU Goldberg, David; Doug Monroe
ART Key to avoiding gridlock?
SO Atlanta journal
DT November 23, 1995
PG p. E7-E8
KW Advanced traffic management systems; advanced traveler information systems

AB In spring of 1996 Georgia transportation officials will activate a \$137 million advanced traffic management system in the Atlanta area. This system includes roadway sensors, variable message signs and 200 interactive kiosks in hotel lobbies, shopping centers, MARTA stations and elsewhere. It is expected that the system will assist in managing incidents and reducing congestion.

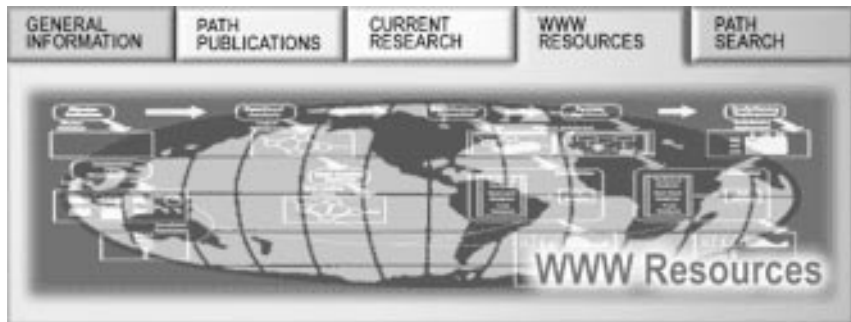
NO 8918

CORP Computing and Control Division Colloquim on Urban Congestion Management (1995: London, England); Institution of Electrical Engineers, Computing and Control Division
TI Computing and Control Division Colloquim on Urban Congestion; Management
DT 1995
SER IEE digest; no. 1995/207
PUB Institution of Electrical Engineers, London
PG 82 p. in various pagings
KW traffic congestion; travel demand management; traffic control

AB This digest contains the text of 12 papers presented at the IEEE Computing & Control Division's colloquim on urban congestion management which was held in London on November 16, 1995. The following topics were covered: (1) Is restraint beneficial; (2) How can control reduce congestion; (3) Helping deserving modes; (4) Driver and traveller information.

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PATH on the Internet



PATH on the Internet

It is a common observation in the publishing industry that we are undergoing the biggest revolution since the invention of movable type. It has also been remarked that we have actually undergone two such revolutions in the past ten years. The first was the computerization of typesetting, of the process whereby thoughts and ideas became inked images on paper. The second, now in progress, is the elimination of paper, although electronic visual displays need considerable development before the paper mills start shutting down.

For a cheap, portable, robust means of displaying high-resolution graphics that are accessible anywhere, paper can't be beat. But for quick access to vast amounts of up-to-date information, the interlinked amalgamation of electronic devices we call the Internet, with its browsers, gophers, knowbots, and other friendly fauna, will soon dominate the way we acquire, manipulate, and even create new ideas.

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As new papers are published, we are putting complete text and graphics online, generally in both Adobe Acrobat PDF (Portable Document Format) and PostScript. We plan eventually to have our entire list online as well.

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Intellimotion, our quarterly newsletter, is available online both in Acrobat PDF and in HTML. The PDF version is a down-loadable version of the paper *Intellimotion*, but we plan to make the HTML edition better adapted to display on-screen, with colored graphics, longer articles, more recent news, and possibly downloadable videos.

This third post-Gutenberg revolution is still in its early days. The key limitation on what is possible online is bandwidth: how much information can get moved how fast? As bandwidth increases, and as clever workarounds of the bandwidth squeeze become available, PATH will make the most of it.



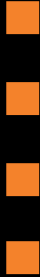
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